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Floodplain Restoration Feasibility Study
La Barranca Unit

Sacramento River National Wildlife Refuge
Cooperative Agreement (#11620-00-J331)

Tehama County, California

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Dan Efseaff, Editor
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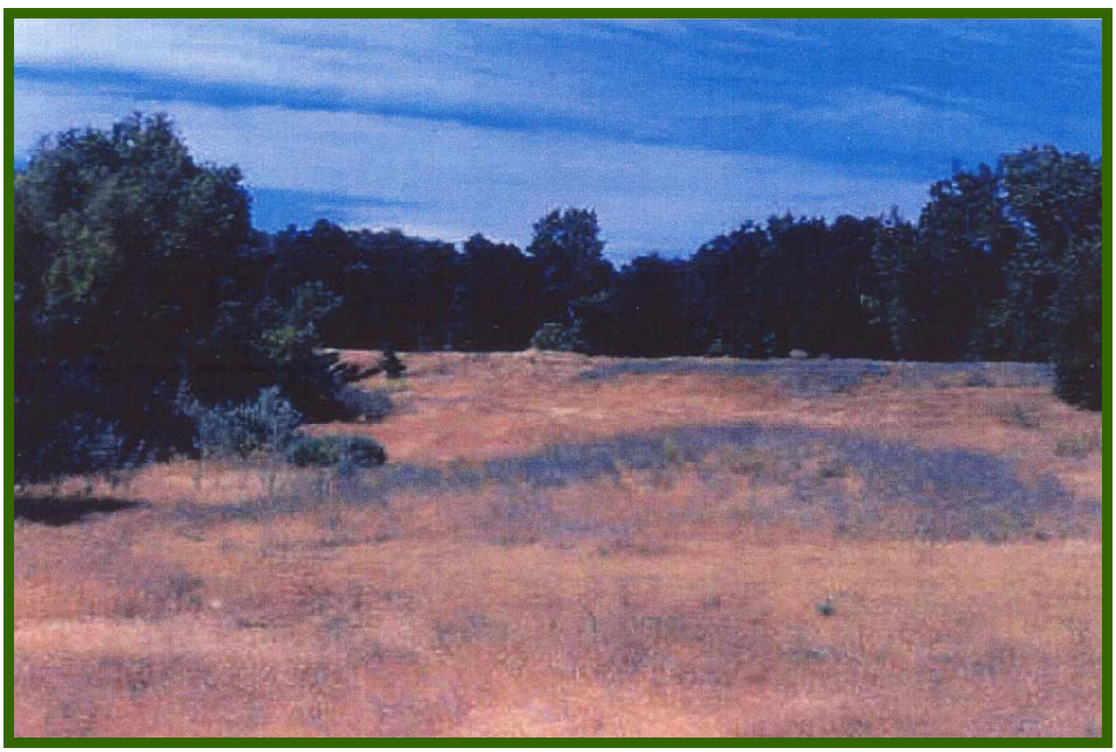

Prepared for the US Fish and Wildlife Service
Anadromous Fish Restoration Program

Floodplain Restoration Feasibility Study, La Barranca Unit, Sacramento River National Wildlife Refuge, Tehama County, California

EXECUTIVE SUMMARY

This feasibility study provides a reconnaissance level assessment to identify management alternatives and data needs for 305 acres of the La Barranca Unit (702.2 acres total) of the Sacramento River National Wildlife Refuge (SRNWR), which is managed by the US Fish and Wildlife Service (USFWS). Sacramento River Partners conducted the study for the SRNWR and the Anadromous Fish Restoration Program (AFRP). Comments from adjoining landowners and interested parties have been incorporated into the study.

The La Barranca Unit is located on the west bank (River Mile 237.5-239.5) of the Sacramento River, approximately 5 miles northeast of Gerber, California and 5 miles southeast of Red Bluff, California. This study focuses on areas of past gravel mining operations. This study is a first step toward examining alternatives to: 1) Address potential native fish entrapment in the existing gravel pits; 2) Reestablish the connection between floodplain and the river; and 3) Enhance the native vegetation on the site. The study used available information and fieldwork to assess the site's current topographic, vegetative, and aquatic conditions.

Numerous pits and mounds from past gravel mining operations are concentrated in the middle of the site, and may pose entrapment threats. Some of these areas are relatively small, but the riverside gravel pit (7.5 acres) and the internal gravel pit (13 acres) appear to pose significant threats, because of their size, exposure to frequent flooding (less than a 2-4 year flood frequency), and limited drainage.

Several grading alternatives reduce the entrapment threat in the riverside gravel pit, but need additional study to consider the environmental tradeoffs before implementation. Connecting the riverside gravel pit to the river at 84' (option 1 of Alternative 1d) provides a good combination of reducing entrapment risks, while maintaining the existing riparian vegetation. Grading of the minor features can be completed with refuge equipment, and require far less analysis of the impacts.

The removal of the levee and filling of the interior gravel pits (Alternative 2b) will benefit natural processes on the flood plain, and reduce the threat of fish entrapment. The preliminary information suggests that the levee removal appears unlikely to cause off-site impacts, but a hydraulic analysis over a larger area should be completed before implementation. The levee removal should be coordinated or combined with the restoration of orchard portion of the La Barranca Unit.

Finally, targeted weed control (Alternative 3b) will limit the damage from non-native plants and enhance the efforts to protect the site's biological integrity. Further steps to examine and implement these suggested alternatives hold the promise of enhancing the site' wildlife potential and reducing salmonid entrapment risks.

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About the cover photograph

Photograph taken near the interior gravel pit on the La Barranca Unit. The vegetation in the background shows mixed riparian forest and valley oak woodland, while the foreground illustrate the typical herbaceous vegetation (mostly annual grasses and star thistle) in this area. A portion of the 900 foot long levee is shown as the the raised area that runs across the middle of the photograph.

Suggested citation:

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ACKNOWLEGEMENTS

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I. INTRODUCTION

A. Project Overview

This feasibility study identifies management alternatives and further data collection needs for a portion of the La Barranca Unit of the Sacramento River National Wildlife Refuge (SRNWR). The US Fish and Wildlife Service (USFWS) manages the National Wildlife Refuge system. The La Barranca Unit is located on the west bank (River Mile (RM) 237.5-239.5) of the Sacramento River, approximately 5 miles northeast of Gerber, California and 5 miles southeast of Red Bluff, California (Figure 1). The entire unit occupies 702.2 acres. This study will evaluate the available data, identify management alternatives, data gaps, and recommend further actions on the eastern portion of the unit (305 acres), beyond the walnut orchard (Figure 2). This study is a first step toward examining alternatives to:

- Reduce the potential of native fish entrapment (especially salmonids) associated with past gravel mining operations.
- Reestablish the connection between floodplain and the river.
- Enhance vegetation on the site.

This feasibility study will suggest alternatives that address these issues, although they may require further analysis and development before implementation. The detailed information in this study provides supporting information for any future Environmental Assessment on site.

B. Goals and Purpose of Feasibility Study

This report provides a reconnaissance level assessment of the site and provides management recommendations. This report is intended to:

- Document current physical attributes of the site.
- Provide information of existing native and non-native vegetation, assess the potential for native species recruitment, and devise a plan for the removal of non-native invasive plant species.
- Identify areas of potential fish entrapment due to former gravel mining and recommend potential actions to minimize entrapment.
- Report findings on the nature and extent of analysis needed to examine the hydrological effects (such as changes in roughness, and direction of flow), under current conditions, proposed action conditions, and the removal of the existing levee and the re-connection of the floodplain and river.
- Assess the site's role in salmon spawning and spawning gravel recruitment.
- Characterize some of the concerns that adjacent landowners and other interested parties may have about future work on the site.
- Develop supporting information for NEPA requirements such as an Environmental Assessment.

This information and analyses are intended to provide a basis for sound management decisions for the project area.

C. Cooperative Relationships

The US Fish and Wildlife Service owns and is responsible for the long-term management of the La Barranca Unit. The Anadromous Fish Restoration Program (AFRP) provided funding for this project. The AFRP was created under the Central Valley Project Improvement Act (CVPIA), which amended the Department of Interior's Central Valley Project (CVP). The USFWS signed a cooperative agreement (#1162000J331) with Sacramento River Partners to complete this study. As the lead AFRP entity, the Red Bluff Fish and Wildlife Office provided valuable expertise for this study. In addition, a variety of individuals representing various organizations also helped develop information for this study.

II. DESCRIPTION OF STUDY AREA

This section reviews the known information on the site. Section IV presents the results of additional investigations into the site's topography, fishery resources, and vegetation.

A. Location and Setting

The La Barranca Unit (T26N, R2W, Sec. 6-7, T26N, R3W, Sec. 1, 11 and 12) is located on the west bank (River Mile 237.5-239.5) of the Sacramento River, approximately 5 miles northeast of Gerber, California and approximately 5 miles southeast of Red Bluff, California (Figure 1). The entire unit occupies 702.5 acres. This feasibility study focuses only on the eastern portion of the site that encompasses approximately 305 acres that were impacted from gravel mining operations (Figure 2). The western area of the La Barranca Unit is currently managed as walnut orchards and is not part of the analysis. The La Barranca Unit is the northernmost property in a nearly 10-mile long strip of land in conservation ownership (Figure 3).

The bank of the Sacramento River defines the eastern and southern borders of the project area (approximately 8,700 feet). Opposite the northern tip of the project area is Blackberry Island (RM 239L), just below the project area is Todd Island (RM 237). A road between the project area and the orchard defines the western boundary.

B. Land-use History

No known prehistoric Native American resources have been recorded in this area, but the Nomlaki are known to have used the surrounding area (Bayham, 2001). In 1844, Josiah Belden obtained the El Rancho de La Barranca Colorada as a land grant from the Mexican government (Bayham, 2001). La Barranca means ravine in Spanish and probably refers to the numerous swales that parallel the Sacramento River across the project area and the rest of the unit. The swales are overflow channels of the Sacramento River. Colorada most likely refers to the red soil found in Red Bluff area or the sediment that may have been brought in during flood events into the swales.

Although the rest of the La Barranca Unit was developed for orchards between 1978--1984 (USFWS 1992), the coarse soil conditions and frequent flooding in the project area limited use to cattle grazing and hunting. We found evidence of a livestock fence

Figure 1. Project Location, La Barranca Unit.

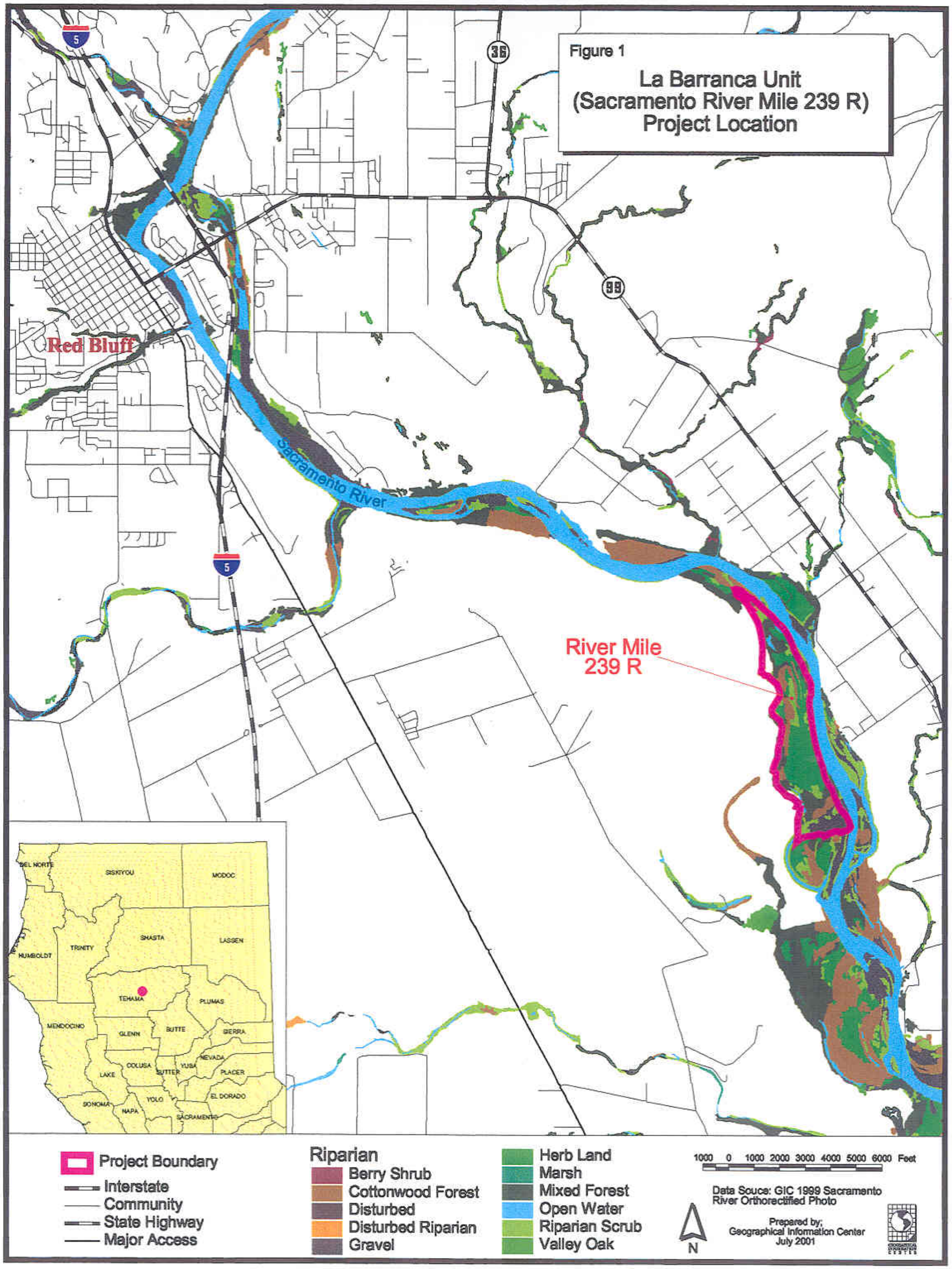
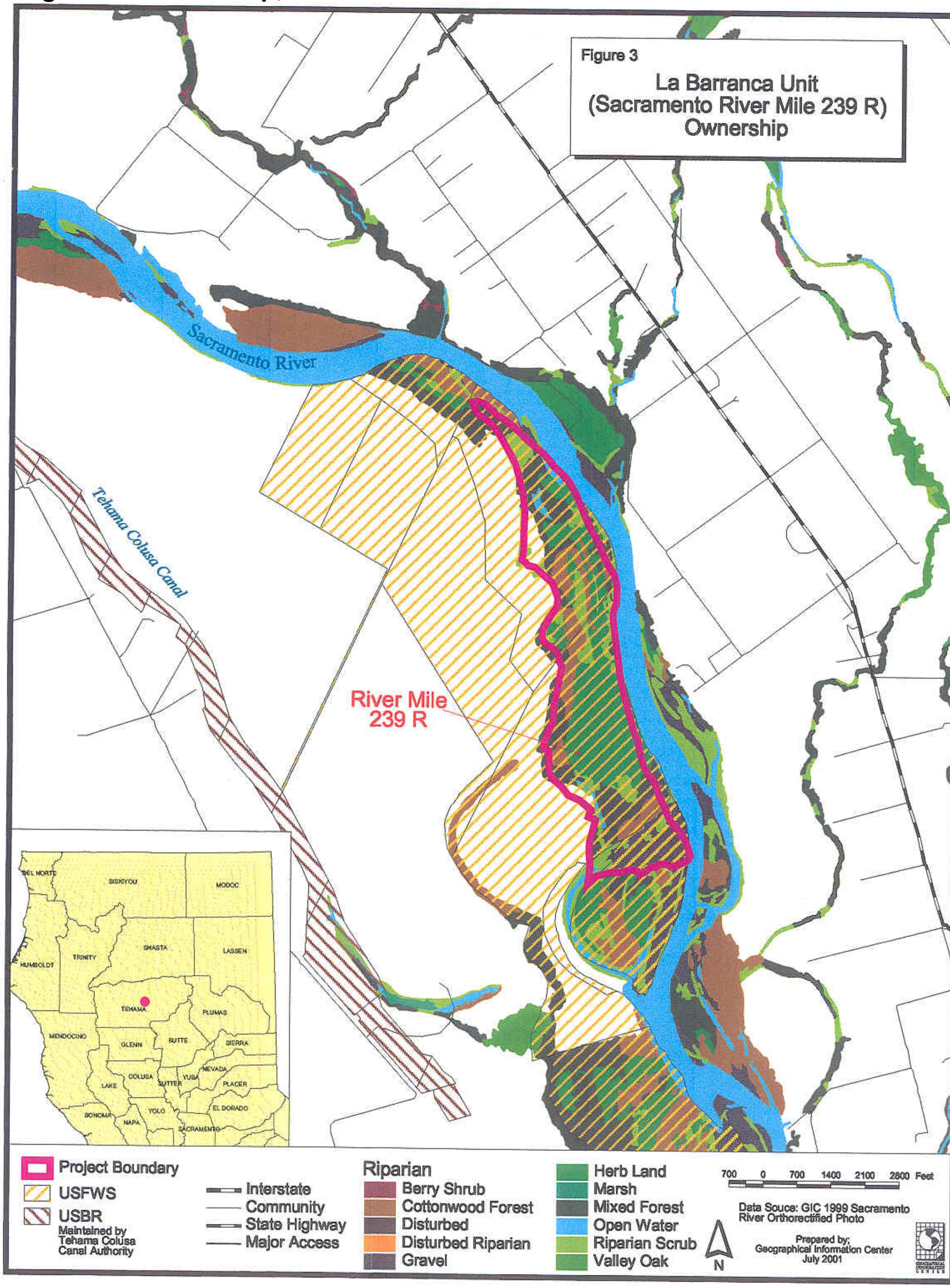


Figure 2. Project Area, La Barranca Unit.

Figure 3. Ownership, La Barranca Unit.



on the north end of the property during a vegetation survey. Prior to 1965, sheep grazed the site. Cattle grazing began in 1965 and ceased after 1985 (personal communication, Chuck Crain).

We have compiled a good aerial photographic record of the site from 1938 (Figure 4), 1958 (Figure 5), and 1976 (Figure 6). The most notable feature of the property is a 2,800-foot long elevated road (1,400 feet) and levee (900 feet) that originates along the north end. The elevated road follows the orchard border and rises 2-3 feet above the orchard. The levee diverges from the border of the orchard and turns south (Figure 1 in Appendix II). In this area the levee rises 5-12 feet above the surrounding ground surface. The levee quickly tapers down to grade just south of the main access road. The landowner constructed the elevated road and levee in the 1960's (material may originated from the gravel mining operations). The levee does not prevent floodwaters from inundating the orchard, but appears to protect the orchard somewhat from erosive flows and the deposition of sediment or debris (Figure 7 1970 flood photo). The orchard is unleveled and still contains evidence of overflow channels.

Gravel extraction pits and scraper marks are quite prominent in the 1976 aerial photograph. Gravel extraction ceased in mid 1980's (personal communication, Chuck Crain). Today remnants of gravel mining activities seem to be concentrated in the middle third of the site. Several pits and mounds are concentrated around the end of the levee, and are evident in the middle of the aerial photographs. For example, long strips curve through the middle of the site in a north and south alignment in the 1976 aerial photograph (Figure 6). No gravel mining activities appear to have taken place at the northern tip of the project area, although this area would be subject to the greatest forces during flood events which may mask minor gravel extraction activities.

The gravel appears to have been used for general building purposes, for spawning gravel in the Single Purpose Canal (SPC) and the Dual Purpose Canal (DPC) (USFWS 1998), and possibly as road base for I-5. The dates of extraction correspond to the construction of the SPC and the DPC that are associated with the Tehama Colusa Canal (USFWS 1998). The canals were intended to serve as spawning habitat for salmonids, but are no longer in use. The canals still contain gravel and cobbles.

In 1993, the Nature Conservancy purchased the 702.5-acre property from the Harriet D. Baldwin Living Trust and transferred it to the USFWS as a unit of the Sacramento River National Wildlife Refuge. We do not have documentation of when the trust acquired the property. At the time of purchase, approximately, 422 acres were in walnut production, 28 acres in almonds, and 252.5 acres in riparian habitat, which has since increased because of river movement. The agricultural portion of the property continues to be farmed and will be eventually phased into riparian forest. The USFWS manages the project area as wildlife habitat.

Figure 4. 1938 Aerial Photograph, La Barranca Unit.

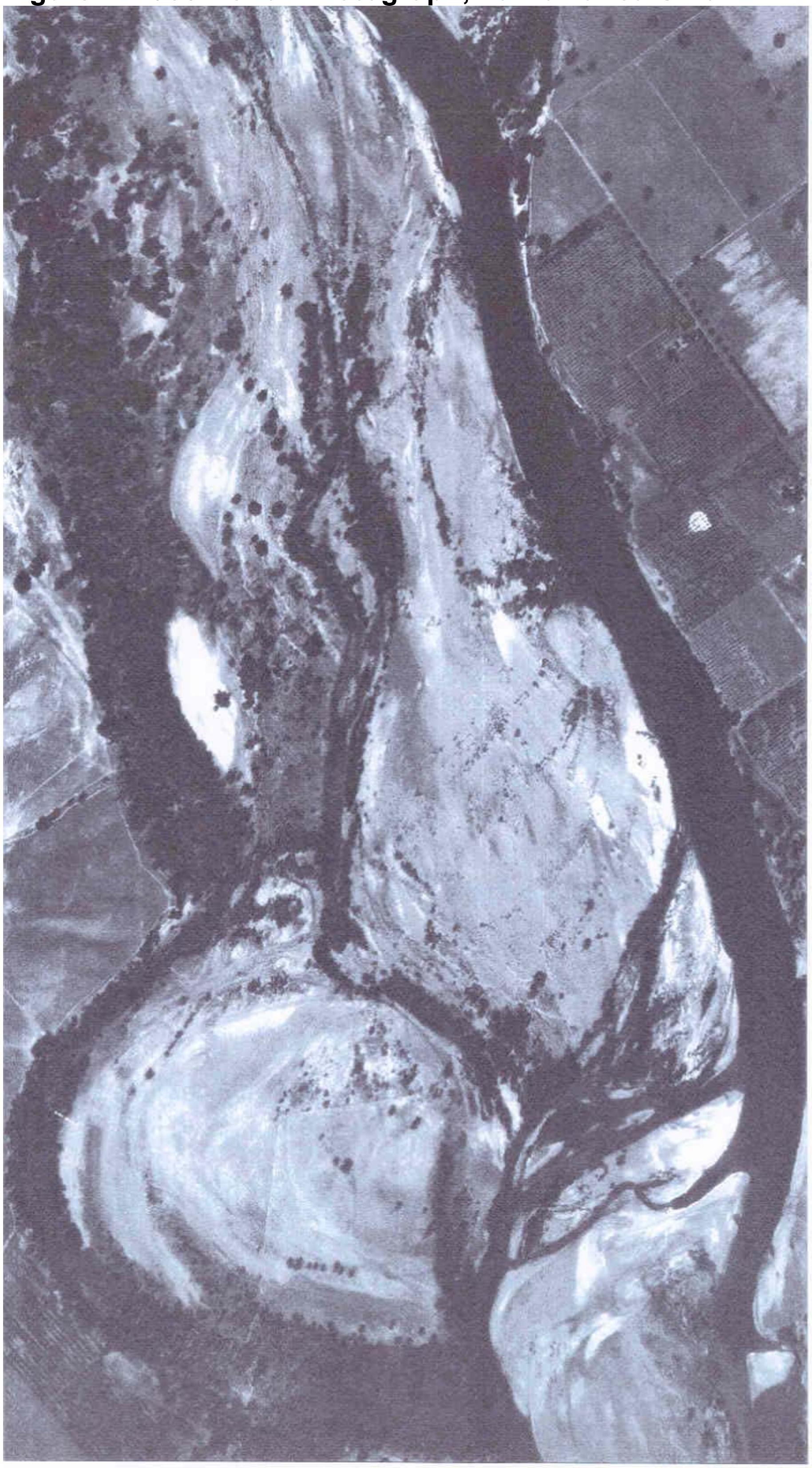


Figure 5. 1958 Aerial Photograph, La Barranca Unit.

Figure 6. 1976 Aerial Photograph, La Barranca Unit.

Figure 7. Aerial photograph of the 1970 flood at the La Barranca Unit.

C. Climate

The La Barranca Unit experiences a Mediterranean climate, with hot, dry summers, and moist, cool winters. Based on data collected in Red Bluff:

- Average annual minimum (45.9°F) and average maximum temperatures (81.7°F) (GHCN 2001).
- Average minimum winter (38.2 °F) and maximum summer temperatures (94.6°F) (GHCN 2001).
- Average rainfall total (22.3 inches per year with most of it falling in the winter) (NCDC 2001).

D. Geology

The Sacramento Valley is a large, northwest-trending structural trough that is filled with a thick layer of sediment originating from the Jurassic and Holocene periods (Bailey, 1966). These older, more consolidated, erosion-resistant formations (Tehama, Riverbank, and Tuscan) bracket the active river channel and limit river meander. These formations provide geological control to river movement because they do not erode easily. Close to the river, newer, undifferentiated alluvial deposits such as the Modesto formation overlay the older formations and allow the river to migrate (Gowans 1967). These younger deposits consist of relatively young, coarse textured sediments and soils (Gowans 1967). The project area is composed predominantly of these relatively young deposits, while the orchard to the west is considered part of the historic meander belt (Figure 8). Most of terrace on the opposite riverbank is comprised of the Modesto formation, but is underlain with the more erosion-resistant Tuscan formation.

E. Soils

Soils on the project area consists of River wash, Columbia loamy fine sand, and Columbia complex, channeled (Figure 9). River wash, found in channels of intermittent streams and of active streams, occupies most of the sparsely vegetated areas of the site. River wash consists of coarse deposits of sand and gravel. In some locations, the gravel is consolidated and weakly cemented.

The Columbia soil series, formed in alluvium from sedimentary, metamorphic, and igneous rocks, are found on recent floodplains along the Sacramento River. They are subject to overflow during winters of high rainfall (Gowans 1967). Columbia loamy fine sand is found close to the swales adjacent to the gravel pit pond and near the levee. Columbia complex, channeled is found near the levee and in a mixed grassland-woodland area south of the levee. These soils are prone to scouring because of the presence of fine-textured material and proximity to main channels. Table 1 summarizes the typical soil conditions and limitations of soil series found at the La Barranca Unit.

Figure 8. Geologic Features of the La Barranca Unit.

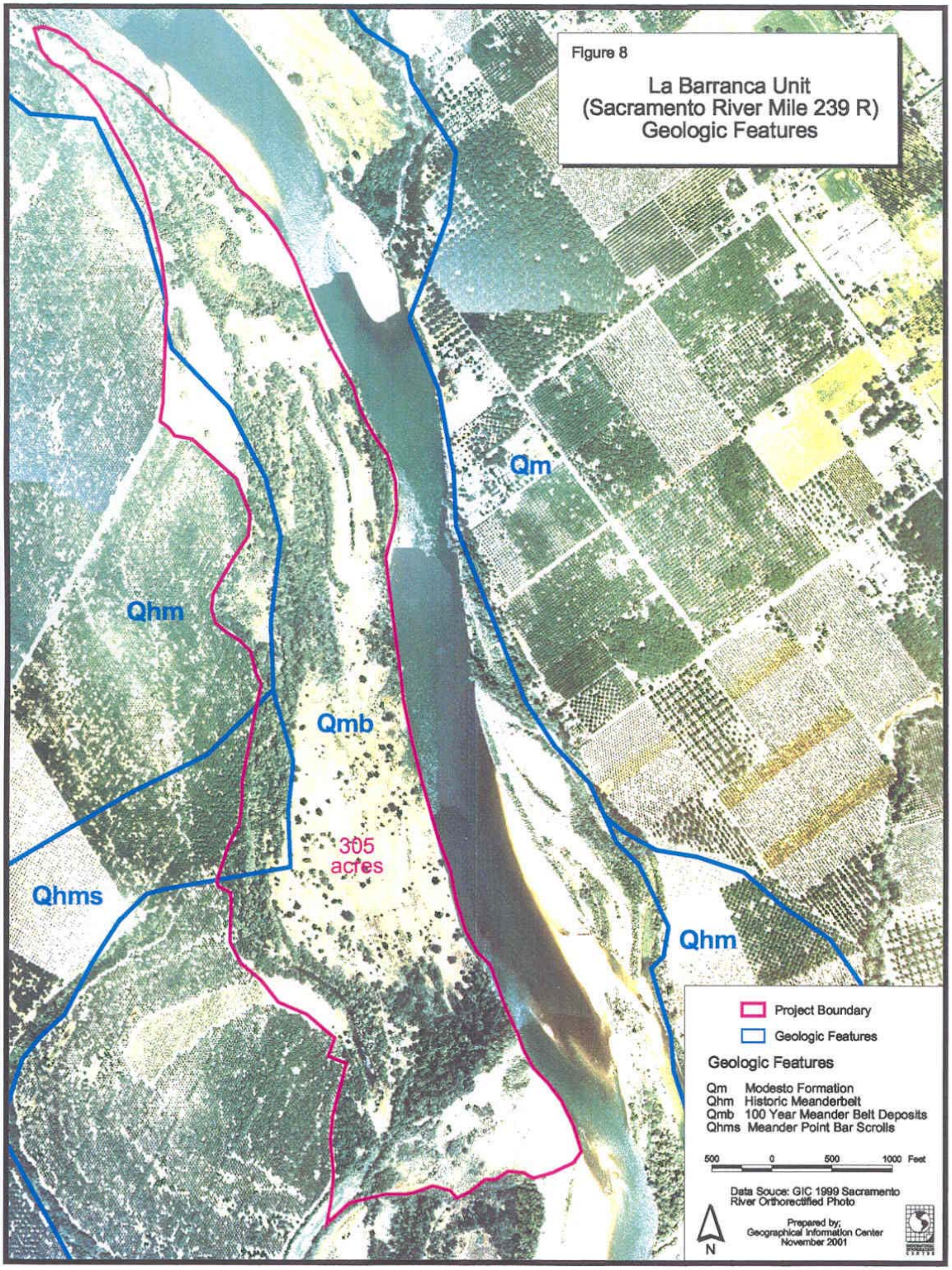


Figure 9. Soil Series found at the La Barranca Unit.

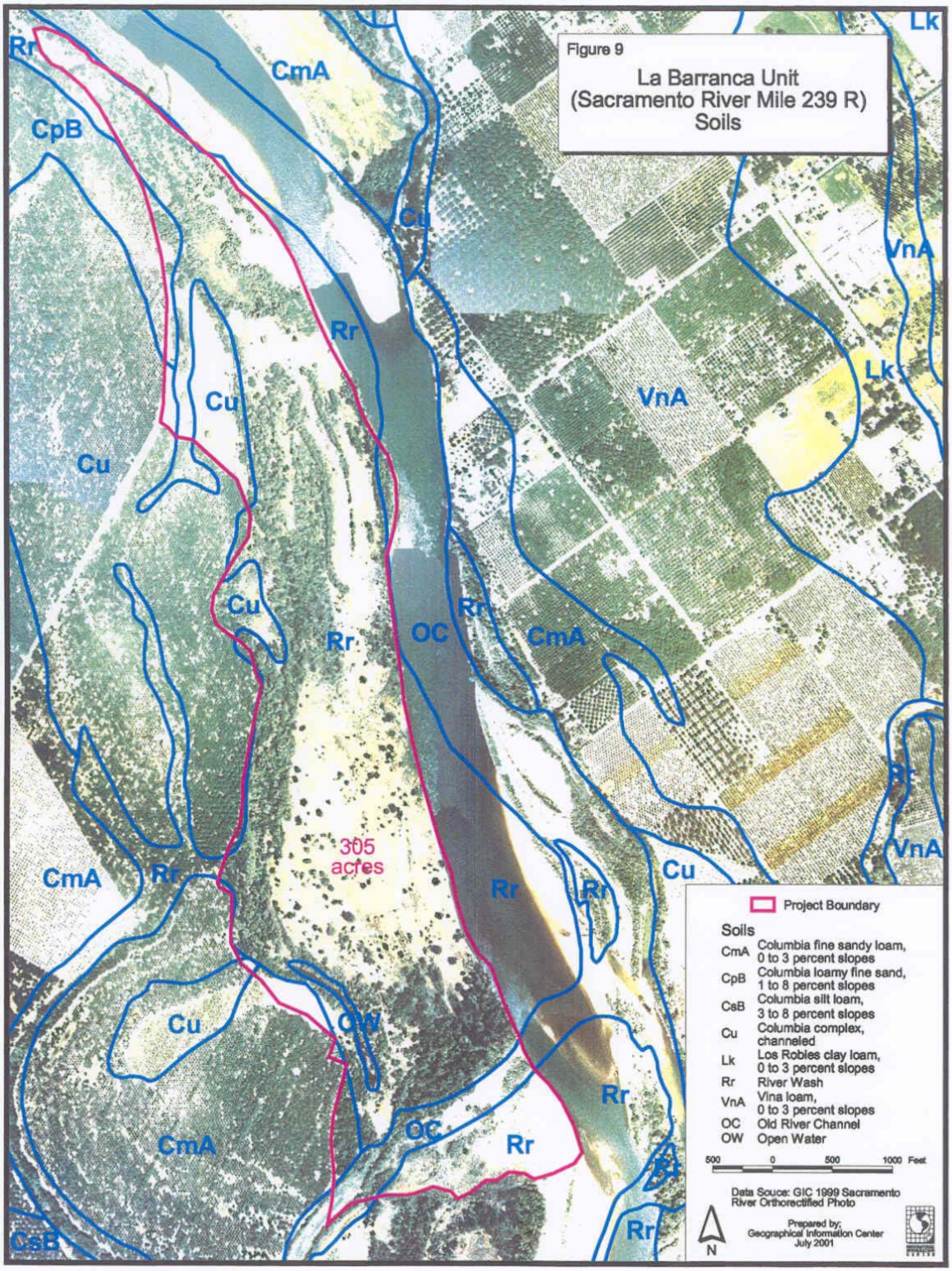


Table 1. Summary of typical soil conditions from the Soil Survey of Tehama County (Gowans 1967) on soils found on the La Barranca Unit, Sacramento River, California.

Soil Property	Columbia Loamy Fine Sand	Columbia Complex, Channeled	River Wash
Mapping unit	CpB	Cu	Rr
% Slope	1-8%	Not specified	Not specified
Texture	Loamy fine sand	Consists of various amounts of fine sandy loam, loam and silt loam	Sand and gravel
Depth of soil	Very deep	Very deep	Not specified
Drainage	Well-drained	Well-drained	Not specified
Permeability	Moderately to Moderately Rapid	Moderately to Moderately Rapid	Not specified
Available water capacity	Moderate	Varies, according to texture and depth to water table	Not specified
Limitations to plant growth	Soil too droughty unless irrigated; fairly short intervals between irrigation, slight erosion hazard, runoff very slow to slow	Subject to scouring because of flooding, erosion likely if left bare	Subject to scouring because of flooding

F. Geomorphology

La Barranca represents the transition of the Sacramento River to a fully meandering river starting at about river mile 238.5. Upstream, from RM 243-238.5, the river is relatively stable with a relatively low slope (0.00050) and low bank erosion (DWR 1998). The river is generally straight with gravel bars forming at several points and no cut off chutes or oxbow features are apparent on recent photographs (Figure 8). Downstream of this area (RM 238.5-231), the river becomes more sinuous, the slope increases (0.00076) and erosion is relatively high (DWR 1998). A variety of channel features such as cut-off channels, anabranches (a channel that branches off from the main stem of the river, often forming islands) abandoned channels, and oxbows are common in this stretch of the river.

Erosion and deposition are balanced within this reach, although the total rates are reduced (DWR 1994). The operation of the Central Valley Project limits the flood flows and bed load of the river in this area. This overall pattern applies to the site, with the deposition of fine material in the gravel pit areas being the possible exception. The abundance of gravel on the site, and the fact that the gravel was extracted suggest that past flood events deposited prodigious amounts of gravel.

Evidence for these larger river patterns and the effects of gravel extraction are evident on the site. The 1912 Army Corps of Engineers map shows the general river course relatively unchanged, while the river downstream has migrated dramatically. Minor changes in the north are apparent from comparison of river position from the 1967 soil survey with the 1997 aerial photograph (Figure 9). For example, a gravel bar has formed adjacent to Blackberry Island (opposite the site on the north end), sediment has deposited on the far northern edge of the site, and the river has moved westward just downstream of the new gravel bar.

These subtle changes contrast with the dramatic changes on the southern end of the project area. For example, the current aerial photograph shows a cut-off channel at RM 237. In 1976, this channel was the main stem of the river (Figure 6), but gravel now connects the project area to a former island in the river. On the ground, recent surface erosion or deposition appears minimal. Much of the gravel in the swales are weakly cemented and past depositional areas tend to contain existing vegetation. These observations were made considerably after the most recent major flood event (1997).

Parallel flood channels run across the north end of the property, while to the south the topography shows the effects of river migration with flood channels oriented at a variety of directions relative to the current position to the main channel. This pattern is consistent with the Sacramento River's transition from a mostly straight river with scattered gravel bars to a much more sinuous, complex channel. Coarse material deposited on the project area restricted riparian plant growth to areas immediately adjacent to the river or along the numerous swale channels. The ample gravel deposited made this an attractive location to conduct aggregate mining.

Past gravel mining operations altered the site's flow patterns. The swales from the north drain into a former gravel pit (the riverside gravel pit) that has since become a wetland. The interior gravel pits are located on the landward side of the levee. These areas are the focus of the topographic study. Figure 1 in Appendix II (GMA 2001) shows the location of the riverside gravel pit (east of the levee) and the interior gravel pit (west of the levee). To the south, the swales consolidate into one major one on the western side of the project area, although other more subtle channels apparently created during gravel mining operations are evident on the open areas. The southern pond appears to be a natural feature as it appears in the 1958 photographs, apparently before gravel extraction.

G. Hydrology

The hydrology of this reach changed with the advent of the Central Valley Project (DWR, 1998). However, the tributaries greatly influence the hydrology in this reach and help establish and support relatively healthy riparian vegetation. Although some of the most important tributaries such as Antelope, Mill, and Deer Creeks, join the Sacramento River downstream of the site, several unregulated streams influence flood flows in this stretch (DWR 1998), providing biologically important flood flows and sediment sources.

Figure 10 shows the flooding frequency based on modeling results (the southern portion of the map) and photographic evidence (the northern portion of the image) The modeling did not extend northward of RM 238. These patterns are somewhat coarse, but provide a good overall picture of inundation. Based on photographic analysis by the

Department of Water Resources (DWR), most of the project area including the area on the landward side of the levee (interior gravel pits) is inundated during 2.5-year flood events (Figure 10). The levee does not prevent floodwaters from entering the interior gravel pit areas, during the 2.5-year magnitude events. The previous landowner most likely built the levee to limit high velocity flows, preventing the deposition of debris and sediment on the orchard. We will detail drainage patterns in the results of the topographic survey.

H. Vegetation

A more detailed discussion of site vegetation follows (in Section IV C Vegetation Assessment), but we will introduce the general patterns of vegetation here. Figure 11 delineates the 3 main communities within the project area:

- Grassland/Savanna/Gravel Bars
- Forest/Woodland
- Wetland/Open Water

The first category represents areas with few trees that are dominated by mostly non-native annuals. These open areas represent recently deposited gravel bars (on the south of the site), relatively high areas with thin soils (overlying gravel) or weakly cemented gravel (i.e. the large open area), or areas where gravel extraction activities are still apparent (i.e. points near the access road). Gravel extraction and the building of the levee may have removed any topsoil in these areas leaving inhospitable growing conditions for woody species.

Much higher densities of woody species are found in the areas with deeper soils or with apparently better access to the water table. Almost all of these forest and woodland areas grow along the swales or in other relatively low areas. In several areas just south of the main gravel pit, the scraping of topsoil and/or gravel extraction suppresses the establishment of riparian trees.

Although the wetland/open water areas are relatively small they are important ecologically. Three areas appear to hold water year-round and support aquatic and lush riparian vegetation. These areas are from top to bottom on Figure 11: the riverside gravel pit, the southern pond, and the cut-off channel. Other pits hold water seasonally. The southern pond lies within a slough and may have been enlarged by gravel extraction but it appears to be a natural feature. The cutoff channel, which lies south of the project area, is connected to the Sacramento River to the south.

I. Wildlife

1. Avian surveys and sightings

The USFWS and Point Reyes Bird Observatory (PRBO) conducted a number of avian surveys on the project area during 2000 and 2001. A complete species list from these surveys is provided in Appendix III. PRBO observed a relatively high species diversity and richness (35 riparian bird species) during point count surveys at the La Barranca Unit. Many resident bird species that appeared frequently included spotted towhee,

Figure 10. Flood Reoccurrence Map of the La Barranca Unit.

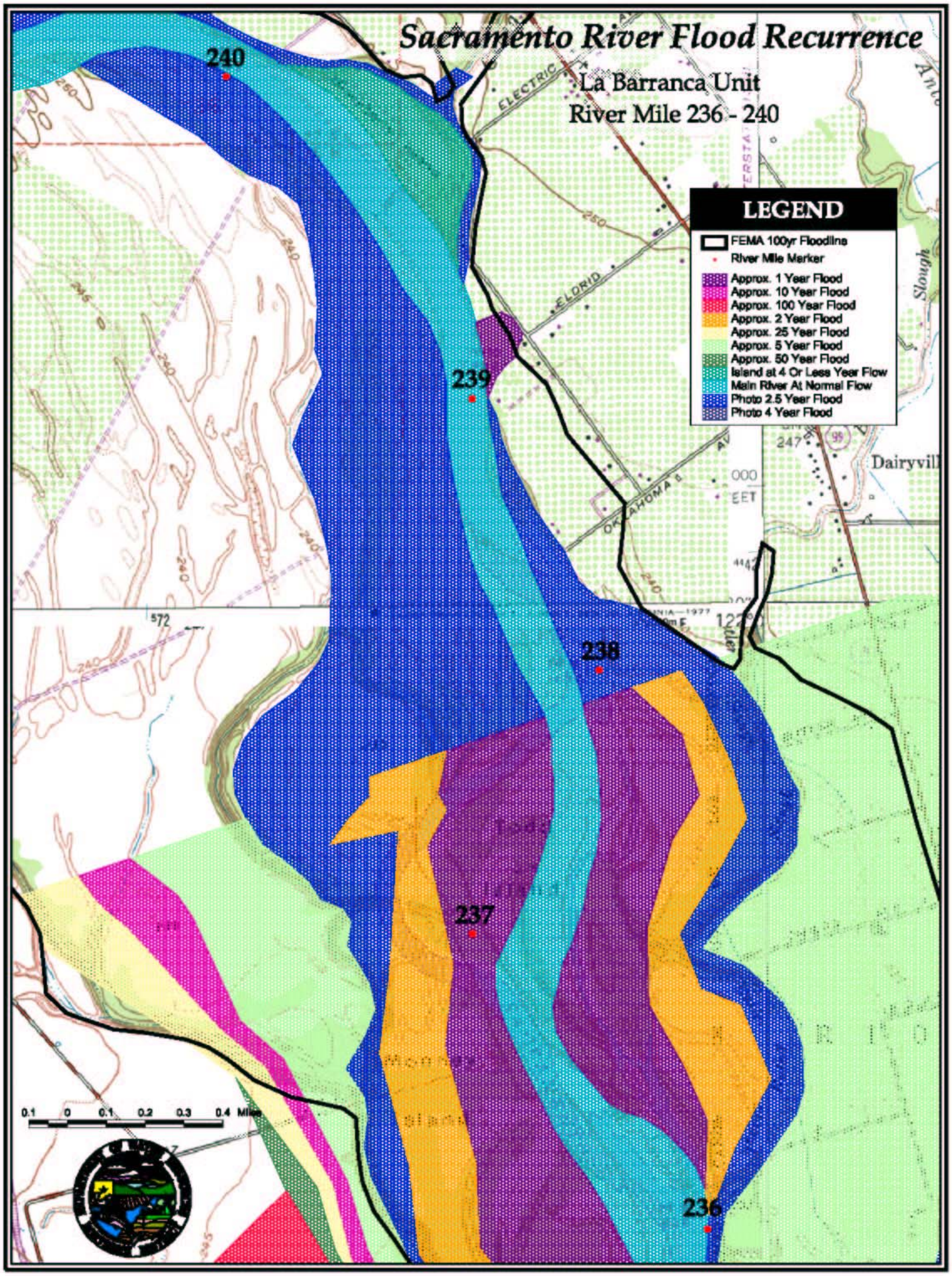
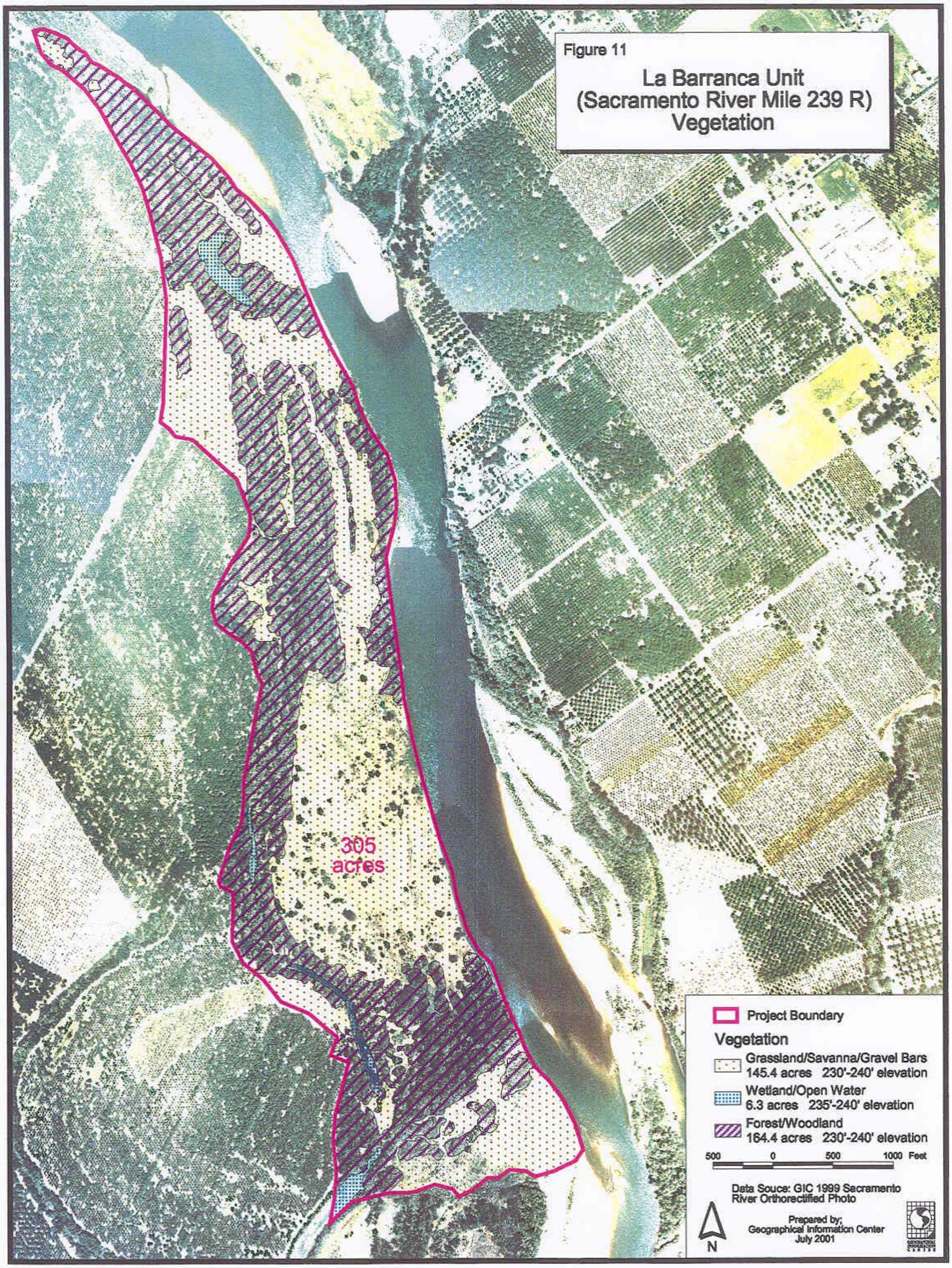


Figure 11. Existing Vegetation at the La Barranca Unit.



Nuttall's woodpecker, Bewick's wren, and oak titmouse. Migrant species found in the riparian zones comprised of ash-throated flycatcher, black-headed grosbeak, Bullock's oriole, black-chinned hummingbird, and Lazuli bunting.

USFWS Sacramento River National Wildlife Refuge Complex executed two winter avian surveys, observing 37 different bird species. Common bird species found in plots included scrub jay, ruby-crowned kinglet, golden-crowned sparrow, western bluebird, and spotted towhee. Tundra swans and starlings were predominantly sighted flying over these plots. Dominant species found in the river channel composed of common golden eye, common merganser, American widgeon, and Greater yellow legs and red-shafted flicker. Birds found outside of plots were California quail, western bluebird, Oregon junco, and yellow-billed magpie.

2. Other potential wildlife

As part of a 10-mile long riparian corridor protected under public ownership, the La Barranca Unit has excellent wildlife potential because of its proximity to the river and high diversity of vegetative structure. The project area provides a wildlife corridor close to the Sacramento River. The site can potentially support a variety of mammalian wildlife species such as mule deer, jackrabbit, raccoon, opossum, bobcat, river otter, striped skunks, ring-tailed cat, red and grey foxes (J. Silveira, personal communication), and elderberry plants on the site may provide habitat for the valley elderberry longhorn beetle.

J. Aquatic Organisms

1. Salmon redd surveys

The California Department of Fish and Game (CDFG) conducts fixed wing aerial surveys for salmon redds between Redding and Princeton (D. Killam personal communication). The information in this section comes from these surveys.

The La Barranca Unit lies in the stretch between the Red Bluff Diversion Dam and the Tehama Bridge in Los Molinos. On average 5.8% of the winter run population has spawned in this stretch from 1987-2000. This area provides relatively unsuitable spawning habitat for winter run Chinook salmon, which mostly spawn upstream near Anderson.

On the other hand, this section provides suitable habitat for spawning for fall-run Chinook. Between 1969-2000, on average, approximately 18.1% of the fall-run population spawn in this stretch. Most redds are concentrated upstream of RM 238, where the river contains more riffles, fewer deep pools, good spawning substrate, and adequate oxygen levels. For example, the downstream end of the gravel bar at Blackberry Island at RM 239.5 offers one of the best spawning locations for fall-run Chinook. Near the La Barranca Unit, Department of Fish and Game observed clusters of 20 to 30 groups of redds in 2000. Downstream of the unit, spawning is greatly reduced because of fewer riffles.

2. On-site aquatic organism use

Although disconnected from the main channel of the Sacramento River, the gravel pit pond, and south pond provide potential habitat for aquatic organisms. Dense wetland vegetation surrounds the gravel pit pond and thick emergent aquatic vegetation covered the water surface in the oxbow. However, both isolated ponds have warmer temperature water that is favorable to non-native aquatic species that may lead to increased competition or predation of native fishes by non-native fish.

III. MATERIALS AND METHODS

A. Data Collection and Sources

As a reconnaissance level study, this report compiled readily available information. However, to adequately develop management recommendations, we collected information on three strategic topics:

- Topography
- Aquatic resources
- Vegetation

Each of these topics provides critical information for the analysis of entrapment hazards and developing management or data collection recommendations.

B. Topographical Survey

Topographical information is critical in assessing the entrapment potential for the site. The Army Corps of Engineers have apparently collected, but not processed, the data to generate 2-foot contour intervals of this reach of the river. Unfortunately, this information was not available for this study. Because the topographical information is critical to assessing entrapment hazards and developing alternatives, we contracted with Graham Matthews and Associates (GMA) to complete a topographical survey and develop conceptual grading alternatives (Appendix II).

Given the limited scope of this report, we focused only on the area around the large gravel pit and levee as the most strategic areas from an entrapment and floodplain reconnection standpoint. During March and April 2001, GMA initiated the topographic surveys using a Topcon AP-L1A Robotic total station. The dense riparian vegetation hampered data collection and cross sections were required to complete the mapping. GMA completed sampling the targeted area in 10 days.

C. Aquatic Resource Evaluation

On March 27, 2001 two USFWS biologists from the Red Bluff Fish and Wildlife Office conducted a cursory survey of water bodies on the site: the gravel pit pond, the south pond, and the oxbow (Appendix IV). The survey was limited to observation of terrestrial and aquatic species associated in these areas. The survey was not designed as a comprehensive evaluation of the ponds, but does provide some basic information on pond conditions. Documenting salmonid entrapment would require sampling immediately after an adequate flood event. No flood events during 2001 were sufficient to fill the ponds with river water.

D. Vegetation Assessment

We preformed a series of vegetation surveys in the spring and fall of 2001. The surveys allowed us to ground-truth aerial photographs of the site, and develop a list of common species. The purpose of the site survey was to:

- Describe the vegetative communities on the project area.
- Develop a list and rank common plant species found within each community.
- Identify invasive non-native species of management concern and recommend control measures.

The communities were described on a site-specific basis and also listed in terms of classifications designated by Holland (1986) and Sawyer Keeler Wolfe (1995).

IV. RESULTS

A. Topographic Survey

Although the topographic study targeted less than a third of the project area, this area is the most critical from a fish entrapment and floodplain reconnection standpoint. Appendix II presents the topographic study (GMA 2001), but we will highlight some of the study's notable findings and outline the grading alternatives. Figure 1 in the GMA report illustrates the position of the riverside gravel pit, levee, and interior gravel pit. Also of interest is the existing site topography in the targeted area (Sheet 2 in Appendix II).

1. Riverside gravel pit

The riverside gravel pit occupies approximately 7.5 acres (GMA 2001). The swales and what appears to be a ramped road for gravel extraction are located in the north or upstream side of the pit. Multiple swales drain into the gravel pit, but outlets for the gravel pit are not well defined. The inlet drainages appear to allow water in when the river rises to 87 feet (however the topographical survey did not include the beginning of the drainages) and begin to fill the gravel pit. As the river rises to an elevation of 94 feet, water from the pit begins to drain. A sizeable pool remains as the river level falls. Given the topography of the pit area, the pool created would stretch over 1,000 feet long, 350 feet wide, and up to 10 feet deep (roughly 75 acre-feet). Sheet 2 in Appendix II shows the gravel pit profiles (numbered 1 and 2) for the inlets and outlets of the riverside pit.

A precise estimate of how often this pit floods would require a hydraulic model to evaluate pit and swale elevations and flood frequency. However, DWR data from flood events and modeling suggests that much of the site is inundated every 2-4 years. Because the pits and swales are at the lowest elevations, they experience flooding more frequently than higher areas, but a frequency of 2-4 years appears reasonable.

Our surveys indicate that past flood events have brought in between 3-10.5 feet of fine material in the pit area. These fine sediments amount to approximately 40,000 cubic yards of material, since mining operations ceased.

2. Interior gravel pits and levee

The gravel pits inside (landward side) the levee occupy about 13 acres. This area forms a right triangle stretching at its widest point 540 feet from the levee west toward the orchard and roughly 1,000 feet in the north south direction. Because the levee stops just south of the road that bisects the middle of this area, the southeast boundary of this area is not well defined but is generally below the surrounding grade. Elevations between 85-90 feet support existing riparian vegetation. Disturbed areas above that elevation are devoid of vegetation except for scattered annuals.

Based on the topographical information, the levee blocks flood water when flows are below 100 feet, but when the river rises above this elevation; water runs around the south end of the levee. Water drains to the west and south into adjacent orchards. Even during these events, however, the levee prevents high velocity flows from entering the interior gravel pits. However, when water flows fall below 94 feet, drainage from the interior gravel pit ceases, and a temporary pond that is up to 9 feet deep occupies most of this interior gravel pit area.

3. Other areas

Observations during site visits suggest that areas outside of the sampling area may also collect water after flood events. These range in size from less than a few hundred feet to a couple of acres. These areas are relatively shallow in depth (<18 inches). Examining the entire project area topography to the level of detail considered above is beyond the scope of this study, however, these areas are also likely to trap water after flood events.

B. Aquatic Resources Evaluation

Results of the cursory survey of the two ponds and the oxbow are presented in Appendix IV and summarized in Table 2. With the possible exception of hitch in the riverside gravel pit, only non-native fish species were observed. The survey did not indicate the presence of native fishes such as Sacramento sucker *(Catostomis occidentalis),* Sacramento pike minnow *(Ptychocheilus grandis),* Chinook salmon *(Oncorhynchus tshawytcha),* and steelhead *(Oncorhynchus mykiss),* but any entrapped in the pits would likely survive for a relatively short period of time.

Table 2. Summary of March 2001 cursory survey of aquatic resources (Appendix IV).

Parameter	Riverside gravel pit	Southern pond	Oxbow
Estimated water temperature (°F)	60-70	60-70	50-60
Estimated water clarity (inches)	6-8	6-8	>8
Substrate	Thick mud	Mud	Mud
Aquatic vegetation	Thick emergent vegetation (Appendix V)	Aquatic vegetation minimal	Thick emergent vegetation
Aquatic animals observed	Mosquito fish (*Gambusia affinis*) and possibly hitch (minnow family) tree frog (*Hyla regilla*), bullfrogs (*Rana catesbeinana*)	Bluegill (*Lepomis marmorata*) Northwestern pond turtles (*Clemmys marmorata marmorata*)	Bull frogs (*Rana catesbeinana*), crayfish (*Decapoda spp.*), Northwestern pond turtles (*Clemmys marmorata marmorata*)

C. Vegetation Assessment

As discussed earlier the project area can be split into three main communities:

- Grassland/savanna/gravel bar
- Wetland/open water
- Forest/Woodland

Table 3 describes some of the features of these areas. As part of the site survey we compiled a species list with a ranking of abundance (Appendix V). We will discuss the traits of each of these areas below.

1. Grassland/savanna/gravel bar

These are relatively open areas with trees widely scattered or absent. Collectively, these areas occupy approximately 145 acres (45%) of the project area. Thin soils or coarse substrates and relatively long distances to the water table define these areas. Areas with deeper soils or that are closer to the water table support forest or wetland species.

On the north end of the project area, relatively small openings within the forest or along the road and levee support scattered, large valley oaks, clumps of sandbar willow, and an understory of mostly non-native plant species such as rip-gut brome, star-thistle, and Himalayan blackberry.

In the middle of the site, the three strip-like openings in the savanna (Figure 11) cut for access roads and/or gravel extraction currently function as flood-channels during high water events and contain a semi-cemented gravel or cobble with little soil. This low productive savanna encompasses most of the southern part of the site. Shallow channels run parallel to the river across the open area and also contain a weakly cemented gravel and cobble substrate. Outside of the shallow channels, soil covers the gravel and annual grasses dominate the vegetation. This subtle substrate difference makes a dramatic difference in vegetation (Plate 1). Areas with deeper soils or slightly lower elevations support savanna and woodlands. The density of woody species increases to the south.

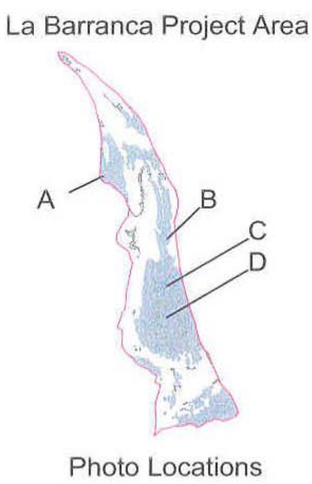
Many species typical of upland or foothill areas can be found in these areas, including California buckeye, naked buckwheat and another unidentified species of buckwheat, monardella, brickellia, and elymus (Sitanion) species (Appendix V). Lichens are present on cobbles. These species are uncommon on the lower reaches of the Sacramento River, but their association on La Barranca suggests a greater influence from foothill seed sources and relatively stable conditions (minimal erosion and sedimentation), despite the frequent flooding. The most southern part of the site is a recently deposited gravel bar that supports willow scrub vegetation.

Table 3. Characteristics of designated vegetation communities on the La Barranca Unit, Sacramento River National Wildlife Refuge.

Description	Grassland/Savanna/Gravel bar	Wetland/Open water	Forest/Woodland
Area (acres)	145.4	164.4	6.3
Location on project area	In areas with gravel or thin soils with limited moisture during the growing season. Some areas were created from gravel mining operations.	Large gravel pit area, riverside gravel pit, southern pond, oxbow.	Along swales and at elevations below 85-90 feet.
Dominant species	Highly variable depending on specific areas of site. Rip gut brome (*Bromus diandrus*), naked buckwheat (*Eriognum nudum*), medusa head (*Taeniatherum caput-medusae*), and sandbar willow.	Duckweed (*Lemna spp.*), yellow water weed (*Ludwigia peploides*), yellow willow along margins.	Fremont cottonwood, valley oak.
Potentially invasive plant species	Arundo (*Arundo donax*), tamarisk, ailanthus, yellow starthistle (*Centaurea solstitialis*), pepper weed (*Lepidium latifolium*), medusa head (*Taeniatherum caput-medusae*).	Cocklebur (*Xanthium strumarium*), medusa head (*Taeniatherum caput-medusae*), cattail (*Typha spp.*)	Ailanthus, arundo, Black walnut, vinca, Himalayan blackberry
CNPS Vegetation Series [1]	California annual grassland series Other areas not well-defined under the CNPS system	Bulrush-cattail series Cattail series	Black willow series Fremont cottonwood series Mixed willow series Valley oak series
NDDB/Holland type	Riparian Scrub (Narrow leaved willow) (63180)	Marsh and swamp (52000)	Riparian forests (61000), Great valley cottonwood forest (61410), Great valley mixed riparian forest (61420)

[1]Based on descriptions developed by Sawyer and Keeler-Wolf (1995) for the California Native Plant Society (CNPS).
NDDB Natural Diversity Database.

Plate 1. Photographic examples of Open Areas at the La Barranca Unit, Sacramento River, RM 239R.



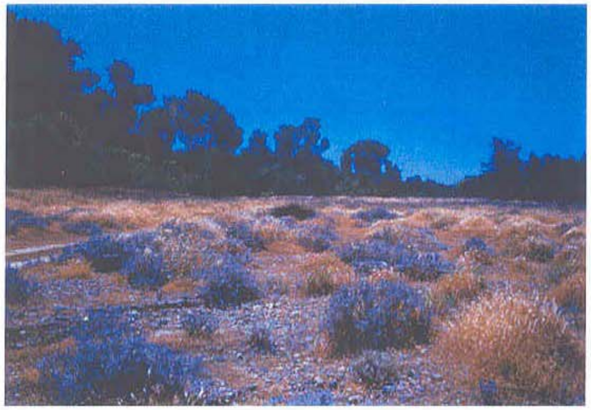


Photo A (August 2001) Topsoil was removed in this areas. Buckwheat (*Eriogonum spp.*) is found in clumps.

Photo B (August 2001) Gravel mining is evident throughout the open areas.

Photo C (August 2001) Large California buckeye in open areas in the south.

Photo D (August 2001) Thicker soil contains annual grasses (on the left), thinner soil allows native buckwheat and tarplant vegetation (on the right).

2. Forest/woodland

Riparian forest and woodland occupies areas below an elevation of 85-90 feet. This vegetation is composed of Fremont cottonwood, black, yellow, arroyo, and sandbar willows, Oregon ash, black walnut, valley oak, elderberry, with Himalayan blackberry a frequent understory species. Variants of this vegetation are defined based upon different relative abundances of these species that are correlated with depth to water table and flow characteristics:

- Sandbar willow type occurs on low gravel (point) bars along the edge of the channel. Severe scour is typical during high flows. These areas appear to be strongly influenced by a high water table.
- Yellow willow type occurs behind the sandbar willow, on older point-bar surfaces and in flood-channels. Less-severe scour allows the trees to grow in an upright form. A high water table also influences this vegetation.
- Cottonwood/walnut/valley oak type occurs on the highest surfaces where scour is minimal. We found blue wildrye and Santa Barbara sedge as understory species in some areas of the site.

The area's geomorphology influences vegetation patterns. To the north, many valley oaks grow on the top of the parallel flood channels while yellow willows dominate the bottom of these channels. To the south, deposition and erosion are much more evident and the topography is more complicated with flood channels oriented at a variety of directions relative to the main channel. Cottonwood and black walnut (and a more open understory) grow abundantly. The non-native Tree-of-Heaven is common at the south end of the property. Some photographic examples of common woodland forest types are presented in Plate 2.

3. Wetland/open water

Wetland areas are found at the lowest elevations. The oxbow has the most direct connection to the Sacramento River, whereas water in the riverside gravel pit and the southern pond is seasonally recharged with surface runoff and flood flows. Both ponds hold water during the driest part of the year, suggesting close proximity to the water table.

Beavers have colonized the riverside gravel pit and their activities have modified the vegetation in and around the pit (Plate 3). By suppressing the growth of willows and cottonwoods and channelizing the wetland, this area supports the most diverse number of plants on the project area (Appendix V). These permanent water bodies support aquatic plants such as water primrose, duckweed, water fern, and cattails. A thicket of yellow willow and Oregon ash surround the pit. The beavers eat the cattails and willows, thus maintaining open vegetation.

4. Non-native invasive species

As we completed the site survey, it became apparent that we should mention the non-native species on the project area. Although non-native herbaceous species are found all over the site and certainly influence native habitats, a few species are of special concern

Plate 2. Photographic examples of Forest/Woodland Areas at the La Barranca Unit, Sacramento River, RM 239R.

La Barranca Project Area

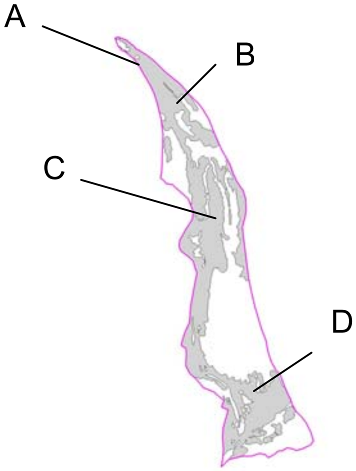


Photo Locations

Photo A (August 2001) Open canopy in riparian woodland with native grass understory.

Photo B (August 2001) Solid stands of riparian forests in northern section.

Photo C (August 2001) Young stand of sandbar willow (*Salix exigua*).

Photo D (August 2001) Closed canopy in riparian forests in south.

Plate 3. Photographic examples of Wetland/Open Water Areas at the La Barranca Unit, Sacramento River, RM 239R.

La Barranca Project Area

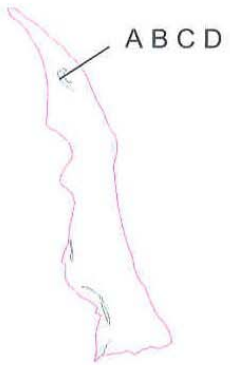


Photo Locations

Photo A (August 2001) Dense vegetation surrounds wetland perimeter. Beaver activity allows for a more open area.

Photo B (February 2001) Surface runoff drains and fills wetland in the winter.

Photo C (August 2001) Network of channels created by beavers. Water depth approximately 3-4" deep.

Photo D (February 2001) Beaver lodge near center of wetland.

Plate 4. Photographic examples of Invasive Species found within the La Barranca Unit, Sacramento River, RM 239R.

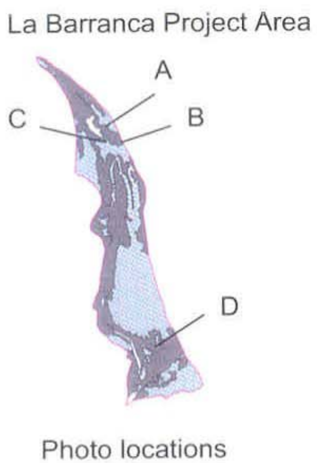


Photo A (August 2001) Giant reed (*Arrundo donax*) infestation.

Photo B (August 2001) Small cluster of salt cedar (*Tamarix spp.).*

Photo C (August 2001) Starthistle (*Centaurea solstitialis*) in understory near forest areas in the North.

Photo D (August 2001) Young Tree-of-Heaven (*Allanthus altissima*) saplings growing under shade of mature cotonwood trees..

even though they may currently occupy relatively small areas or are present in small numbers. Once established these invasive species are likely to:

- Decrease the quality of wildlife habitat.
- Become increasingly difficult to control.
- Out compete native plants and prevent their recruitment.
- Provide a seed source for invasion of other riparian areas.

Interestingly, most of the invasive species are either associated with the gravel mining operations and are found in the middle and southern end of the site. Table 4 highlights the species of greatest concern due to their aggressiveness or habitat degradation potential. Some examples of these species on the site are shown on Plate 4. The non-native black walnut (escaped from English walnut rootstock) behaves aggressively and should also be considered for removal.

Table 4. Non-native species of concern found during the vegetation survey at the La Barranca Unit.

Scientific Name	Common Name	Frequency Found	Location Found
Ailanthus altissima	Tree of heaven	1-3	Forest and woodland
Arundo donax	Arundo or giant reed	1-2	Forest, open areas, wetland
Catalpa speciosa	Northern catalpa	1	Savanna and around wetland
Centaurea solstitialis	Yellow starthistle	2-4	Open areas and near wetland
Cirsium vulgare	Bull thistle	2	Wetland
Ficus carica	Fig	2	Forest
Lepidium latifolium	White-top, pepperweed	1-2	Forest and open areas
Phytolacca Americana	Pokeweed	2	Forest
Rubus discolor	Himalayan blackberry	1-3	In all communities
Tamarix spp.	Tamarisk	1	Forest and open areas
Vinca major	Greater periwinkle	1	Forest

Each identified species was assigned to a class to designate frequency: 1-rare/infrequent, 2-frequent, 3-abundant, and 4-common. Species selection based on potential invasiveness, many other non-native plant species were found on the project area.

D. Potential Third Party Concerns

We made considerable effort early in this project to notify adjoining neighbors, and other interested third-parties (see Appendix I for a list of some of individuals contacted). Most respondents appreciated the opportunity to comment and contribute to the plan during the initial phases of the project, and expressed an interest in being kept informed as other options are developed. Some of the general concerns are summarized below:

- That the river channel would migrate away from riverfront homes, but generally supportive if levee removal resulted in lower flood stage.
- Desired access to Refuge property.
- Noted concern if the project included changes to the riprap placed immediately upstream on the west bank upstream and directly opposite the project area.
- Influence of levee removal on changes on flood patterns downstream and westward of site.

Some of these comments have been addressed in this study and others will be considered as analyses are completed for selected alternatives. As a next step, we suggest that these parties be kept informed of project progress and be able to offer input before the USFWS initiates substantial management alternatives.

E. Description of Alternatives

During the course of this study, several alternatives arose that address the fish entrapment, floodplain reconnection, and vegetation management issues. Each one of these is described below with a brief analysis as to its potential benefits.

1. Fish entrapment/Topographic restoration (on the riverside of the levee)

a) Alternative 1a – No Action

This scenario is defined as no earthmoving, monitoring, or other actions intended to address the fish entrapment issue. Under this scenario, the potential for entrapment remains although it is likely to diminish over time (on the order of decades) as sedimentation occurs. This alternative may place anadromous fish at risk, although the magnitude cannot be quantified at this time.

b) Alternative 1b – Monitoring and rescue

This alternative would develop a monitoring and rescue plan. Selection of this alternative does not preclude other alternatives and may generate information that supports more intensive actions. The monitoring plan should specify the sampling protocol (i.e. timing, event, procedures) and detail potential rescue efforts, such as access, collection, costs, transport, and release. Implementation of the plan would be triggered by flows exceeding the 2.5-year flood event.

Ideally, the monitoring would document the magnitude of fish entrapment, and demonstrate the need for rescue efforts or for more permanent remedies (i.e. grading). Effective monitoring and rescue efforts may be possible in the smaller pits, but are not realistic for the riverside gravel pit (J. Williamson, personal communication) given the difficultly and hazards posed by the dense vegetation, depth to the bottom, and uneven surface. The monitoring effort in this area may produce presence information, but is unlikely to provide conclusive, timely, or cost-effective population data.

c) Alternative 1c - Cut and fill minor features

Throughout the site there are several relatively minor features that could serve as potential entrapment areas. In one of these areas, a USFWS refuge staff member found an adult salmon after a flood event (R.Vega personal communication). This alternative involves the minor regrading of areas on the riverside of the levee to remove or reduce some of the smaller potential entrapment areas. Some of the larger mounds support valley oak and other trees and these areas could be avoided with work concentrating on connecting obvious basins to existing swales to provide improved drainage. Note that this is not leveling these areas, but simply grading them to fit into existing features.

We did not estimate total volume of material, but the work could be completed in 1-2 days with refuge equipment. The total area occupies less than 5 acres and is concentrated in the pit and mound area just south of the riverside gravel pit and along areas further south where drag scrapers operated. Some areas with native and non-native annuals would be disturbed, but no perennial riparian vegetation would be displaced. Although these features are small and may not pose significant entrapment hazards, this option is relatively inexpensive and would reduce some of the obvious visible effects of gravel extraction and may discourage some of the rouge gravel collection from the project area.

d) Alternative 1d - Cut and fill riverside gravel pit (3 options)

GMA examined 3 options that represent a range of effort to cut and fill the gravel pit area (Appendix II). Any of these options are likely to require an Army Corps of Engineers permit. One alternative, excavating a channel from the gravel pit to the river was briefly examined and rejected because:

- A narrow channel deep enough (at an elevation of 79-80 feet) to allow drainage would be unstable and unlikely to remain intact during a flood.
- Fine silts that have accumulated from the gravel pit could be flushed into the river during flood events.
- Excavated fill would have to be distributed in other areas of the site or hauled offsite.

The three remaining options are summarized in Table 5. Each option has an associated map attached in Appendix II. The options are arranged in order of volume of material moved. Option 1 creates a narrow channel and raises the wetland to provide an outlet for drainage. Option 2 raises the level of the wetland and creates a wide channel for drainage. This area could support riparian vegetation if sediment from the pit is stockpiled, but it would remove some of the existing vegetation. Option 3 is more intensive and cuts and fills the pit and the area east of the pit to the same grade. Most of the vegetation on the east and south side of the pit would be removed although it would create a larger area that could support riparian vegetation.

2. Levee modification/Flood plain reconnection

a) Alternative 2a - No Action

No change to the levee or raised road would occur under the no action alternative. Under this alternative, the connection between the river and floodplain would remain limited. Because the levee will not be maintained, in time the levee will erode. Because the erosion will not be controlled, the direction of flow cannot be controlled and the erosion may cause some undesirable effects, such as exposing the pits between the levee and the orchard, creating a more significant entrapment hazard than now exists.

Table 5. Comparison of gravel pit extraction options (Alternative 1C options) (GMA, 2001) for the La Barranca Unit, SRNWR.

Parameter	Option 1 Fill and Connect Riverside Gravel Pit to River at 84'	Option 2 Fill and Connect Riverside Gravel Pit to Floodplain at 87'	Option 3 Fill and Connect Riverside Grave Pit to Floodplain at 90'
Description	Cut a narrow channel from southeast corner of gravel pit toward river; spread spoils in gravel pit to allow positive drainage.	Create a wide channel on the southeast area of the gravel pit to drain floodwater, and partially fill areas of the gravel pit. The upstream drainages would be filled up to 1 foot.	Cuts and fills a roughly rectangular area that would drain the gravel pit to the river. Grading would reconnect the pit area to an existing swale to southwest. The upstream drainage swales would be filled 1-3 feet.
Area impacted	Southeast corner of gravel pit and land toward river, selected areas of gravel pit.	Southeast corner of gravel pit to river, selected areas of gravel pit, and drainages to approximately 300 feet upstream of pit.	Entire gravel pit area and areas to the east and south, drainages to approximately 500-600 feet upstream of pit.
Channel size	Approximately 50 feet wide on the bottom, 670 feet long, 11 feet deep	Approximately 230 to 500 feet wide on the bottom, 670 feet long, 8 feet deep.	Would create an open area (not a channel) with dimensions of 700 feet wide, 1450 feet long, 4-6 feet deep that joins the river from the east and southeast.
Estimate volume cut/fill (cubic yards)	11,000	42,000	87,000
Affect on entrapment potential	Likely improves current drainage, while maintaining most of existing topography. Relatively small channel can fill during flood events.	Area from existing wetland to river would be on similar grade.	Removes the gravel pit and brings it to a level even with drainage to the river, therefore removes any entrapment hazard.
Riparian habitat impacts	Minimal. Earthwork impacts a narrow area and preserves most of riparian vegetation around wetland. Does not provide additional riparian habitat.	Impacts vegetation around wetland and up the drainages, but would result in a net increase of 6 acres of riparian vegetation if area is restored.	Would remove most of existing vegetation around wetland, but would result in a net increase of 13 acres of riparian vegetation if area restored.
Wetland impacts	Depends on how spoils are distributed, may preserve character of wetland, Additional fill in pond will decrease depth by 0-4 feet.	Would cover areas of existing wetland, and raises bottom of gravel pit 2-10 feet.	Wetland would be effectively covered with 2-11 feet of fill over the bottom of gravel pit.

b) Alternative 2b - Levee removal and filling of interior gravel pit

In addition to the gravel pit options GMA also examined the removal of the levee and the creation of a small setback levee on the road between the orchard and the interior pit area. This option would:

- Remove the levee (approximately 900 feet).
- Fill the interior gravel pit.
- Reconnect to the existing swale within the project area.
- Raise the orchard road (up to 4 feet) to provide the same level of flood protection as currently provided to the adjacent orchards.

We chose to examine the setback scenario, because it would not impact areas outside of the project area. However, the US Fish and Wildlife Service owns the orchard and will eventually restore it to riparian vegetation. Reconnecting the orchard to the river will reinitiate natural processes, benefit wildlife habitat, and on a very local level may reduce flood stage. The levee removal should be timed to minimize disruption to current agricultural activities or future restoration activities.

If levee removal is selected as an alternative for future study, the analysis should consider eliminating the setback levee road and/or regrading the raised road back to the existing topography. Such an analysis should examine the effects of such changes at different flows over an appropriate area. The area and analysis required is beyond the scope of this feasibility study.

3. Vegetation management

a) Alternative 3a - No Action

No weed control or restoration activities would occur under this alternative. Areas that currently require restoration on the project area are small; however, non-native species now established on the site threaten the biological integrity of the site. While these species are currently present in relatively low numbers, will increase without control measures, diminishing habitat conditions and may increase the fire danger.

The implications of this alternative somewhat depend on other activities selected. For example, if the gravel pit is graded no action may result in non-natives colonizing this area. None of the earthwork options, however, are likely to impact the invasive non-natives that we documented on the site.

b) Alternative 3b - Targeted weed control

This alternative would identify and control specific invasive non-native plant species. Although many non-natives are found on the project area, we focus on those of greatest concern. Control measures are likely to be successful at this point in time with relatively minimal cost. Unchecked these species can displace native plant species and degrade wildlife habitat on the site. Once these species dominate a site, eradication becomes difficult and expensive.

This alternative will consist of intensive eradication efforts for two years with monitoring and maintenance thereafter. Specific tasks are to:

- Identify and mark areas/species for treatment.
- Undertake specific weed control efforts (depends on species for most of the woody species would require removal and treatment of stump or new regrowth with herbicide).
- Monitor effectiveness of treatment efforts.
- Follow-up weed control.

Currently, non-natives occupy relatively small areas of the site and weed control efforts undertaken immediately are likely to be much more effective and less intrusive to existing habitat on the site. Pertinent life history information, suggested weed control measures, and other references are provided in Appendix VI. A report specifying the methods use, areas and species treated, and follow-up documentation of effectiveness should be part of this task.

c) Alternative 3c - Revegetation and restoration of cut and fill areas

The project area does not need widespread intensive restoration efforts. However, some revegetation and/or weed control may be necessary if the levee or gravel pit areas are modified to keep non-native plant species from invading these areas. If irrigation is supplied during establishment, these areas can support woody species. Planting these areas to native grass and conducting weed control efforts may be another effective method to excluding invasive species.

V. DISCUSSION

We will provide a synthesis of the site information and develop some likely scenarios based on the current understanding of physical and biological factors. The discussion will focus on fish entrapment, floodplain reconnection, and vegetation management, and later will consider the data gaps and make recommendations based on the current understanding of the site.

A. Fish entrapment potential

Identifying fish entrapment areas is the intersection of the timing and magnitude of flood events, site physical conditions, and life history and behavior of targeted species. As a result of this study, we have good topographic information, but the magnitude of actual entrapment remains undocumented. However, we can use the preponderance of current evidence to suggest reasonable actions. We will examine the potential risk at each of the identified areas.

<u>Riverside gravel pit</u>

Multiple swales in the north direct flood flows into the riverside gravel pit. Once floodwaters drop below 94 feet above mean sea level, drainage from the pit abruptly stops. Based on the topographic analysis by GMA, a seven and one-half acre area would be inundated each time the river stage reached a sufficient height. A sufficient flood to fill this entire area may not happen each year, but flooding is frequent. Based on DWR data (2001), sufficient flood flows occur on the site every 2.5-4 years (or a nearly 50% probability of occurrence every given year). Perhaps more importantly, during the months flooding is likely to occur (December to May), adults and/or juveniles of all races of Chinook salmon are present. Out-migrating juveniles are more likely than adults to be trapped in the pits. Given the abrupt recession limb of the current dam-modified hydrograph after most flood events and the physical layout of the gravel pit, fish may be unable to escape when floodwaters recede. Given the frequency of inundation and the size and drainage patterns of the gravel pit, fish entrapment is a concern in the riverside gravel pit.

Complicating the analysis and implementation of actions are changes the pit has undergone since its creation. Wetland and riparian species have become established in the gravel pit area, creating valuable habitat. When mining ceased, excavated areas below 85-90 feet (because of proximity to the water table), could allow the recruitment of riparian plant species. In the riverside gravel pit, the excavation was deep enough to support wetland species as well. The effects of mining are still evident on more upland areas.

The pit itself has changed too. Between three to ten feet of fine sediment has filled in the bottom of the pit since the 1970's, and eventually natural processes may minimize the effects of the gravel pit. As an extremely crude estimate, the pit would fill to grade, but the process would take several decades, assuming that the current rate of sedimentation applies. Over that time the pit would be subject to dozens of flood events and potential entrapment. River migration such as moving away from the pits or incorporating them into the active channel could also alter the entrapment threat.

<u>Interior gravel pit</u>

The abandoned gravel pits outside the levee also pose an entrapment threat. These pits are not as close to the river and therefore are less likely to reconnect during floods and trap fish. Nonetheless, these are sizeable areas (13 acres), with similar flooding frequency as the rest of the site. Under current conditions the levee blocks direct flows to the interior gravel pit, although water can back onto this area. The eventual or sudden failure of the levee may increase the entrapment risk. Flows below an elevation of 96 feet above mean sea level would no longer flow off of this area and potentially trap fish. Unlike the riverside levee, this area supports only small patches of riparian vegetation (and no permanent wetland), and most of the area is either devoid of vegetation or contains non-native species. The levee also offers a source of fill for grading options, which also reconnects the floodplain to the river and reduces the entrapment potential.

<u>Southern pond</u>

The southern pond appears to be a natural feature developed from the deposition of material associated with channel migration. We have little information on which to judge the entrapment potential of the southern pond, but the connection of the inlets and the grade toward the river for outflows appears far less dramatic than the gravel pits. Outflows are likely to gradually decrease, rather than abruptly cease. The entrapment potential is likely far less than the gravel pits.

Oxbow
Significant fish entrapment is not likely in the oxbow, given the more intimate connection to the river. These backwater channels support warm-water predators, but offer important salmonid rearing habitat.

Miscellaneous gravel mining features
Numerous small pits and mounds associated with gravel mining interrupt the natural drainage of the site, but these are small features and likely pose a minor risk of entrapment.

B. Floodplain reconnection

As mentioned earlier, the levee on the La Barranca Unit does not prevent flooding, even during relatively minor flood events and the pits and gravel mining borrow sites pose risks to fish entrapment. Floodplains provide a selective advantage to native fish because of seasonal food availability, refuge from predators, and refuge from faster flows. Providing access to the floodplain while reducing entrapment risks; therefore benefits native species. Reconnecting the floodplain and river provide clear benefits to floodplain processes and riparian plant succession. Combining restoration with the reconnection of the floodplain will improve the habitat potential of the site. The La Barranca Unit contains some of its historic topographic features (i.e., swales) and has experienced relatively little leveling common throughout agriculture lands. The levee removal will enhance the long-term benefits of restoration on the site.

C. Non-native plant succession

Although the causes are open to interpretation, invasive non-native plants appear to be gaining a foothold on several areas of the project area. Whatever the cause, these potential "system changers" pose a threat to the biological integrity of the site and are of the most concern. These species can out-compete native plants, degrade riparian habitats, and serve as source populations for invading other sites. For example, young saplings and seed-producing adults of ailanthus grow thick under the canopy of trees on the south end of the site. This aggressive species can displace natives (it is shade-tolerant and produces allelopathic chemicals that suppress the growth of other species, resulting in a monoculture. Fortunately, the species identified above are in the early stages of infestation. Control measures initiated now are likely to be successful and cost-effective.

D. Comparison of alternatives

Tables 6, 7, and 8 compare the alternatives in terms of several important factors. The selection of the preferred alternative(s) should be made upon consultation with USFWS staff from the refuge and the fisheries office to prioritize actions on the site.

Table 6. Comparison of alternatives (1) related to the riverside gravel pit on the La Barranca Unit.

Parameter	Alternative 1a No action	Alternative 1b Monitoring and reporting	Alternative 1c Cut and fill minor features	Alternative 1d Cut and fill riverside gravel pit (3 options)[a]
Floodplain processes	No effect	No effect	Reestablishes drainage on site.	No effect on floodplain inside levee. Minor effects associated with reconnecting drainages.
Potential third-party impacts	None identified.	None identified.	None identified.	Potential changes to flood flows or patterns should be addressed in the hydraulic analysis.
Fish entrapment and effect on aquatic resources	Entrapment hazard persists, although cannot be documented under this alternative.	Documents entrapment hazard and can prompt rescue operations. No change on actual entrapment potential.	Possible reduction of minor entrapment hazards. Does not address larger entrapment issues.	Addresses fish entrapment in the riverside gravel pit.
Riparian vegetation	No effect.	No effect.	Possible minor effects on individual plants, but no significant impacts to most of site.	Option 1 minimizes impacts to riparian vegetation. The other options will disturb existing vegetation, but may create areas that will support riparian plants: Option-2 6 acres, and Option 3 - 13 acres.
Wetland	No effect.	No effect.	No effect.	Option 1 adds 0-4 feet of fill, but may maintain some wetland features. Options 2 and 3 would remove wetland.
Data needs	Not applicable.	Proposed monitoring may document entrapment.	No permit necessary, as features are less than 18”. No intensive engineering or hydraulic analysis required.	Army Corps of Engineers (USACE) permit likely. Hydraulic analysis needed to assess impacts.
Relative costs	May generate costs if	Monitoring and sampling plan relatively inexpensive. Cost of rescue operation depends on scale and frequency of entrapment.	Requires 1-3 days of work that could be completed with refuge equipment, affects less than 5 acres. Estimated costs less than $5,000.	Rough estimates of earthmoving costs (without hydraulic or engineering analysis): Option 1: $45,000, Option 2: $85,000, Option 3: $175, 000.

[a]The options are detailed in Appendix II but these are: Option 1 fill and connect riverside gravel pit to river at 84’, Option 2 fill and connect riverside gravel pit to floodplain at 87’, and Option 3 fill and connect riverside gravel pit to floodplain at 90’. Note: earthmoving costs based on estimated costs of approximately $2.00 per cubic yard.

Table 7. Comparison of alternatives (2) related to the levee and interior gravel pits on the La Barranca Unit.

Parameter	Alternative 2a No action	Alternative 2b Levee removal and filling of interior gravel pit
Floodplain processes	No effect.	Enhances contact between river and floodplain.
Potential third-party impacts	None identified.	May impact La Barranca walnut lessee operations. Other potential impacts (changes to flood or debris flows or patterns) should be addressed in the hydraulic analysis.
Fish entrapment and effect on aquatic resources	No effect, maintains entrapment hazard.	Fills gravel pits to grade allowing drainage to existing swales on project area. If the setback levee were omitted, then water would drain into swale in orchard.
Riparian vegetation	No effect.	Enhances potential for recruitment of flood dependent riparian plants. May temporarily impact riparian restoration activities.
Wetland	No effect.	No effect.
Data needs	Proposed monitoring may document entrapment.	USACE permit may be required. Hydraulic analysis needed to assess impacts.
Relative costs	Monitoring and sampling plan relatively inexpensive. Cost of rescue operation depends on scale and frequency of entrapment. The interior pits are far easier to access than the riverside pit.	Rough estimates of earthmoving costs (does not include hydraulic or engineering analysis): $36,000.

Note: earthmoving costs based on estimated costs of approximately $2.00 per cubic yard.

Table 8. Comparison of alternatives (3) related to vegetation management on the La Barranca Unit.

Parameter	Alternative 3a No action	Alternative 3b Targeted weed control	Alternative 3c Revegetation/Restoration on project area
Floodplain processes	Depends on magnitude of infestation.	No effect.	Reduces erosion potential, stabilizes areas subject to earthmoving.
Potential third-party impacts	Weeds on the site could provide a source for invading other sites along the river.	None identified.	None identified.
Fish entrapment and effect on aquatic resources	No effect on entrapment. Some indirect effects if non-natives become dominate (loss of shaded riverine aquatic habitat, food chain effects).	No effect on entrapment. May enhance flood plain habitat.	May enhance created channels or floodplain areas.
Riparian vegetation	Allows identified non-native invasive plant species to become established on the site.	Allows succession to proceed with native plants.	Increases area of riparian vegetation, reconnects forest fragments.
Wetland	Increases chance that wetland will be overtaken by non-native species.	Limits ability of non-native species to invade the wetland.	No effect.
Data needs	None	Identify locations and areas.	Identify areas for replanting (likely built into the exploration of other alternatives).
Relative costs	No initial costs. Control measures initiated later would be more expensive and likely less effective.	Costs likely between $5,000 and $10,000, but difficult terrain and amount of hand-labor may limit area treated. Additional data collection will increase the accuracy of the cost estimate.	Depends on area planted and the amount of care. Costs range between $500 per acre for simply planting cuttings with minimal care to $6,000 per acre for the planting with an irrigation system and weed control for three years.

E. Data Gaps and Additional Data Needs

Depending on the alternatives selected, future action will almost certainly require additional data collection or analysis. Some of the data gaps include:

- Monitoring for the presence of native fish after flood events will document the need for seeking more permanent solutions.
- We recommend a hydraulic analysis of selected alternatives to examine the effects of topographical changes on flood flow patterns and stage height over a larger area than the project area considered for this study.
- Supplementing the topographic information in this study with additional field collected data or with the forthcoming Army Corps of Engineers elevation data, plus the bathymetry data collected by DWR, may allow for the construction of a 2-d hydraulic model, and a broader understanding of the area topography (i.e. on the south end of the project area, and following the old swale that now runs through the orchard).
- The available flood frequency information (Figure 10) is adequate to assess the potential for entrapment but imprecise to judge changes to the levee or the adjacent land and further analysis may guide the design.

River migration may influence the longevity of the gravel pit as an entrapment threat. Future analysis should examine likely migration patterns and the effect on protected banks in the area.

We have adequate data to consider the non-native plant problem, although information related to implementation such as a more extensive survey and quantification of plant numbers or area would provide better information for cost estimates.

F. Conclusions

This feasibility study demonstrates some of the tradeoffs and uncertainties inherent to land management decisions. USFWS priorities for the site will ultimately determine the selection of alternatives, but we provide a range of recommendations based on the study's findings.

<u>Fish entrapment/topographic restoration for the riverside gravel pit</u>

The analysis suggests that river water spills into the riverside gravel pit at a flood frequency of 2-4 years. During sufficient events, a pond with approximately 75 acre-feet of water forms, posing a substantial (but not quantified) fish entrapment risk. The pit currently supports a wetland and riparian vegetation. Given the potential entrapment risk, environmental tradeoffs, and data uncertainties, we recommend several actions that differ from other areas of the site:

- Grade the small extraction areas to existing swales (Alternative 1c). This action will minimally impact existing vegetation, albeit the entrapment reduction is small. This action can also be incorporated into the more intensive grading alternatives, but does not require an extensive analysis.

- Develop and implement a simple monitoring plan (Alternative 1b) to document the presence of native fish as more permanent solutions are developed.
- Prioritize the tradeoffs between the existing riparian and wetland habitat, and the potential for fish entrapment. For at least the riverside gravel pit, eliminating the fish entrapment hazard comes at the expense of existing riparian and wetland habitat, yet the preponderance of evidence suggests that it is a hazard. An Environmental Assessment may provide the appropriate mechanism to fully evaluate the impacts and options.
- Explore the feasibility of returning the gravel in the SPC and DPC to the site.
- Develop hydraulic and geomorphological analyses of selected alternatives, develop specific designs, and list potential required permits. Comparing the hydraulic evaluation with native fish life history patterns may provide additional information on the likelihood of fish entrapment.
- Out of the grading options considered, the option to connect the riverside gravel pit to the river at 84' (option 1 of Alternative 1d) may provide a good combination of reducing entrapment risks, and maintaining the existing riparian vegetation. Variations of this alternative, such as placing the fill in areas other than the wetland, may reduce entrapment risks, preserve the wetland, and simplify the permit process.

<u>Floodplain reconnection</u>

Unlike the riverside pit, linking the levee removal with the filling of the interior gravel pits (Alternative 2b) will benefit riparian vegetation while reducing the risk of fish entrapment. Based on preliminary information, the levee removal appears unlikely to cause off-site impacts. We recommend that the USFWS pursue the levee removal and filling of the internal gravel pits through the following actions:

- Analyze flow patterns and stage height (over an area greater than the area considered in this study) associated with the levee removal and filling of the interior gravel pits (Alternative 2b). Also consider the benefit of regarding the raised road that lies to the north.
- Identify any potential entrapment areas in the orchard area and provide remedies.
- Integrate (and possibly fund together) the levee removal with the proposed riparian restoration of the La Barranca Unit to maximize ecological benefits.

<u>Vegetation management</u>

A variety of potentially invasive plant species are present on the site. Costs of control will increase as these species become more dominant on the Unit. To protect the biological integrity of the site, we strongly recommend that the USFWS immediately initiate targeted weed control efforts (Alternative 3b).

No widespread restoration is currently required, but any earthmoving activities are likely to require rehabilitation or restoration in discreet areas. We recommend that the necessary vegetative work be included within the design phase of any earthmoving activities.

Next steps

The available funding sources and varying data needs may require that the USFWS pursue remedies for fish entrapment, floodplain reconnection, and vegetation management separately.

We recommend an adaptive management approach to consider action for the riverside gravel pit with the consideration of additional information (i.e. any monitoring information, or the results of the hydraulic evaluation) dictating the next logical step (i.e. the need for an environmental assessment, or developing design specifications). As rescue efforts are not likely to succeed, cutting and filling the riverside gravel pit, provides the only feasible remedy for fish entrapment, but additional information is required before the next step is decided.

Linking the level removal with filling in the interior gravel pits will require a hydraulic evaluation, environmental compliance documentation, and a more detailed design. The ecological benefits associated with floodplain reconnection and removing the fish entrapment hazard makes this alternative quite compelling. Implementation of this alternative should be coordinated or combined with the restoration of the orchard area of the La Barranca Unit. Funding for the required studies, environmental compliance, and potential implementation should be sought as a next step.

Although some additional analysis is needed (i.e. the selection of control options, survey and mapping of invasive non-native plants, etc), these measures are related to implementation of the targeted weed control measures. It is imperative that targeted weed control measures be initiated immediately on the project area.

VI. SUMMARY

A. Accomplishments During the Project

This Feasibility Study documents a variety of information that:

- Documented the site's physical attributes and history,
- Noted the existing native and non-native vegetation and devised a plan for the removal of non-native invasive plant species,
- Completed an extensive topographical map of a portion of the site to identify potential fish entrapment areas,
- Develops conceptual grading alternatives to minimize the entrapment potential,
- Compiled information on local salmon spawning areas,
- Incorporated recommendations from the Red Bluff Fish and Wildlife Office, and
- Identified potential issues of concern based on 4 meetings with neighbors and other interested parties.

B. Significant Findings

The scope of this feasibility study is limited, but we were able to make several significant findings:

- Gravel extraction created the riverside (7.5 acres) and the interior gravel pits (13 acres). Swales directly feed into the riverside gravel pit, while water fills in from the downstream side of the levee into the interior gravel pits. These areas create sizeable ponds, which presumably could trap native fish. Both of these areas are subject to frequent flooding (less than a 2-4 year flooding frequency).
- Vegetation on the site can be divided into three general communities, which are defined by distance to the water table and soil characteristics.
- We identified several non-native-invasive plant species that, if left untreated, may damage the biological integrity of the site.
- Areas of the riverside gravel pit support forest and wetland vegetation because of the proximity to water. Higher areas with gravel extraction evident are devoid of vegetation or support non-native annuals.
- The short (less than 900 feet) privately built levee prevents the deposition of debris and sediment and limits erosive flows through the unleveled orchard. Its removal will benefit riparian species, once the area is restored.
- Although Fish and Wildlife Service employees, observed an adult salmon carcass in one of the small pits after a flood, no information documents native fish entrapment in the larger pits. Rescue efforts are possible in some of the smaller pits, but are not likely to be successful in the riverside gravel pit
- Further action to address the entrapment issue appears prudent given the size of the pits, frequency of inundation, and potential for fish entrapment.

We provided recommendations for the three main topics considered in this report:

- A phased approach to address the entrapment issues associated with the riverside gravel pit: 1) monitor for the presence of anadromous fish (Alternative 1b) as more permanent solutions are developed, 2) grade the small extraction areas to the existing topography (Alternative 1c), 3) collect additional information and develop analyses and NEPA documentation to aid with the selection of grading options (Alternative 1d) or the decision to not pursue earthmoving alternatives.
- Complete additional analyses and implement the levee removal and filling of the interior gravel pits (Alternative 2b). The levee removal should be coordinated or combined with the restoration of orchard portion of the La Barranca Unit.
- Targeted weed control efforts against potentially damaging non-native plant species, and incorporating vegetation rehabilitation with any earthmoving activities.

VII. REFERENCES

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VIII. SUMMARY OF EXPENDITURES

Expenses as of 3/31/2002

Consulting	$ 12,687.66
Labor	12,064.53
Travel	866.47
Postage & printing	457.84
Field Supplies	56.25
Overhead	5,487.88
Total Expenses to Date	**$31,620.63**

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Appendix I

Contacts List

List of Neighbors and Interested Parties

NAME	AFFILIATION
Bill Borror	City Supervisor County Clerk's Office
Koll Buer	Department of Water Resources
Stacy Cepello	Department of Water Resources
Bruce Ross	Department of Water Resources
Charles Ohm	Neighbor
Chuck DeJournette	Neighbor
Crain Orchards	Neighbor
Eldon Harms	Neighbor
Jim Dukes	Neighbor
John Ohm	Neighbor
Marc Sanders	Neighbor
Ken & Dorothy Lindauer	Neighbor
John Scott	Neighbor
Mr. Trout	Neighbor
Ms. Woehletz	Neighbor
Robert Harms	Neighbor
Ron & Mary Radford	Neighbor
Vic Brand	Neighbor
Serge Birk	Neighbor
Tim Merrill	Neighbor
Tom McKay	Neighbor
Ernie Ohlin	Public Works Department
Vicky Snowden	The Nature Conservancy

Appendix II

GMA. 2001. La Barranca Gravel Pit Restoration Project, 2001 Conceptual Grading Alternatives. Graham Matthews and Associates. Weaverville, California.

LA BARRANCA GRAVEL PIT
RESTORATION PROJECT

2001 CONCEPTUAL GRADING ALTERNATIVES

Prepared for:

Sacramento River Partners
539 Flume Street
Chico, CA 95928

Prepared by:

Graham Matthews & Associates
P.O. Box 1516
Weaverville, CA 96093
(530) 623-5327

June 2001

LA BARRANCA GRAVEL PIT RESTORATION PROJECT
2001 CONCEPTUAL GRADING ALTERNATIVES

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LA BARRANCA GRAVEL PIT RESTORATION PROJECT
2001 CONCEPTUAL GRADING ALTERNATIVES

INTRODUCTION

The La Barranca Unit Restoration Project conceptual design was developed to address the degraded flood plain conditions within the La Barranca Unit (river mile 238-239.5) of the U.S. Fish and Wildlife Service's Sacramento River National Wildlife Refuge (Figure 1). Within this reach of the Sacramento River, extensive floodplain aggregate extraction and levee construction to protect adjacent orchards has altered natural floodplain conditions.

As a result of these activities, several flood plain features that serve to strand salmonids and other fish species after moderate to high flow events in the Sacramento River occupy the site. These features are illustrated on Figure 1 and consist of an approximately 13 acre interior pond defined by constructed levee features and an approximately 7.5 acre gravel pit. Both features lack positive drainage following inundation and receding flood flows effectively strand any fish that enter these areas during overbank flows. In addition, disturbance of site soils and topography resulting from aggregate mining activities has likely altered the natural abundance and distribution of riparian vegetation at the site.

This conceptual design has been developed to evaluate several alternatives for eliminating the fish traps at the site and to restore the form, function, and structure of the flood plain at the site. The Sacramento River provides important habitat for endangered salmonids and other fish and wildlife species. Restoration of the flood plain form will improve habitat conditions for a variety of life stages of these native wildlife species and remove direct hazards to threatened and endangered fish species. The project alternatives also address recreation of floodplain function for fine sediment retention and increased riparian habitat values.

SCOPE AND OBJECTIVES

This report addresses a range of grading options that will eliminate potential anthropogenic fish stranding features and facilitate riparian restoration at the referenced site. These grading options can be fine-tuned within the range of finished grades presented based on input from riparian and wetland vegetation studies at the site and corresponding topography and soils recommendations.

The objectives of the La Barranca Unit Restoration Project include: 1) elimination of floodplain features that cause salmonid stranding and mortality in former floodplain gravel extraction pits and 2) restoration of native riparian vegetation on floodplain and terrace surfaces by focusing on species that provide canopy cover. To achieve these objectives, project actions will involve restoration of floodplain physical parameters, enhancement of passage for fisheries resources and restoration of riparian and wetland habitat for wildlife.

METHODS

Work elements conducted in developing the conceptual grading alternatives for this project included the following: field topographic surveys, a quantitative assessment of fine sediment available for augmentation of coarse soils, development of a terrain model for the site, and development of alternative grading options to provide positive drainage from the site while minimizing impacts to existing site vegetation. Descriptions of methods utilized in conducting the first two elements are presented below. The remaining elements were completed utilizing AutoCad Land Development Software.

Field topographic surveys were conducted during March and April of 2001 utilizing a Topcon AP-L1A Robotic total station. A total of 10 days were required for the mapping utilizing one and two person survey crew(s). The site was surveyed with control based on an arbitrary datum originating on the elevated portion of the levee access road adjacent to the orchards on the interior of the site (Hub 1, Figure 2). A total of 29 control points were set during the surveys. Locations of the control points and their relative coordinates are presented on Figure 2. Varying densities of topographic survey points were collected within the open and vegetated portions of the site. Survey coverage and survey point density ranges are illustrated on Figure 3. Overall, developing detailed topographic maps of areas with this density of riparian vegetation is extremely challenging. Vegetated areas of the site within the gravel pit and up and downstream portions of the site were surveyed by cutting cross-sections through the vegetation at 100-300 foot intervals, as there is no feasible way technique to accomplish continuous topographic mapping in some of these areas.

Fine sediment depths within the gravel pit were quantitatively examined by probing to coarse gravel at 22 mapped locations with a 0.9' diameter rod. These data were utilized to calculate the volume of fine sediment in the gravel pit that is available for augmentation of coarse soils at the site and/or the volume of material that could be displaced during pit fill operations.

EXISTING CONDITIONS

Existing site features and topography are illustrated on Figure 1 and Plates 1 and 2. All elevations given are based on the arbitrary datum discussed above and presented on Figure 2.

In terms of general observations of soils and vegetation conditions, the elevated and unvegetated portions of the site consist of very coarse alluvial gravels disturbed/graded by historic aggregate mining operations. The site generally supports upland, riparian, and wetland vegetation in portions of the site that have apparently not been disturbed by historic mining activities. Wetland and riparian vegetation is also supported in areas that were excavated during aggregate mining and left with existing elevations ranging from 80-90 feet (arbitrary datum). Primary topographic features of interest in the interior and riverside portions of the site are discussed below.

The primary feature of interest on the interior of the site is the fish stranding area formed by the levee access road separating the orchards from the flood plain and the interior levee. This feature is accessed at high river flows above approximately 100 feet and does not have positive drainage when interior water surface elevations fall below approximately 94 feet. At water surface elevations below 100 feet, drainage of this area occurs to the west and south of the site into the adjacent orchards. As a result, this feature ponds water when interior water surface elevations recede below approximately 94 feet. Lower portions of this area from approximately 85-90 feet support existing wetland and riparian vegetation. As illustrated on the Levee Road Profile (Plate 2), portions of the levee access road are below the interior levee at elevations from 95-100 feet. As a result, the interior levee provides flood protection to the orchards located to the west and south of this area for river flows below approximately 100 feet.

The features of interest on the riverside portion of the site east of the interior and access road levees include the swales entering the site from the north, the gravel pit, the channel leaving the gravel pit, and the drainage swales south of the gravel pit.

The swales entering the site to the north are illustrated in plan view and in cross-sections 1 and 2 on Plate 2. These features are accessed by river flows above approximately 91 feet. These features are heavily vegetated with mature trees as illustrated on Plate 1.

The gravel pit and gravel pit drainage channel are illustrated in plan view and in Gravel Pit Profiles 1 and 2 and cross-sections 4 and 5 on Plate 2. This feature is accessed by river flows above approximately 91 feet and is fed by the drainage swales to the north and the channel at its north-east end as illustrated on Gravel Pit Profile 2, Plate 2. Drainage for this feature is provided by the low point on the south end of the gravel pit perimeter at approximately 89 feet, as noted on Plate 2, and by the gravel pit drainage channel at approximately 90 feet as illustrated on Gravel Pit Profile 1, Plate 2. Fine sediment depths in the gravel pit range from 3-10.5 feet. Probing observations in the pit revealed that coarse alluvial gravels underlie these accumulated fine sediments. Based on the aerial extent of the mapped fine sediments and their depths, the volume of fine material in the gravel pit is approximately 40,000 cubic yards. The top two feet of this material is approximately 7,000 cubic yards. The lowest portions of the gravel pit at approximately 80 feet were at the Sacramento River water surface elevation during surveys in April 2001, but it is clear that the original depth of excavation (another 10 feet lower) was probably well below the thalweg elevation of the river in this area. We believe that all of the fine sediment in the pit has accumulated in the years post-construction.

The drainage swales downstream of the gravel pit provide positive drainage to portions of the site south of the gravel pit and east of the interior levee down to approximately 87 feet as illustrated on cross-sections 6 and 7, Plate 2. These features eventually dissipate in form, south of cross-section 7.

SITE GRADING ALTERNATIVES

Based on the existing site conditions and the restoration objectives of eliminating fish stranding features at the site and improving riparian habitat, several site-grading alternatives have been developed. One grading alternative for the interior fish trap and three grading alternatives for the gravel pit are presented below.

These alternatives cover a range of grading options based on site topography and the constraint of minimizing impacts to existing site vegetation. These grading alternatives can be fine-tuned within the range of finished grades presented based on input from riparian and wetland vegetation studies at the site and corresponding topography and soils recommendations.

An alternative involving excavation of a channel from the gravel pit to the river, without placement of any fill in the pit was briefly examined and then rejected for the following reasons: (1) a narrow channel deep enough (approximate elevation of 79-80 feet) to allow positive drainage from the gravel pit would be unstable and unlikely to remain intact after moderate flood events, (2) a considerable amount of the accumulated fine sediments in the pit could well be flushed into the river during flood flows if positive drainage were provided, and (3) with no fill area in such a design, excavated volumes would need to be hauled somewhere else on the site for disposal.

All earthworks volumes presented include a 30% fill factor. This value was chosen as a very conservative estimate based on previous experience filling in areas containing deep fine sediments with alluvial gravels. Expected fill factors could range from 10-30% depending on site conditions and whether fine sediments are excavated for soil augmentation and the extent of such excavation. The following volume estimates assume fine sediments would be left in place during fill operations. All grading options presented approximately balance in terms of cut and adjusted fill.

Interior Fish Trap and Levee Removal

Grading of the interior fish trap to provide positive drainage is constrained by the downstream swale thalweg elevations (cross-sections 6 and 7, Plate 2). Plate 3 illustrates elements of this option. Removal of portions of the interior levee or the entire levee to approximately 89 feet will be required to assure positive drainage. The option presented on Plate 3 includes reduction of the entire interior levee to 91-93 feet, filling low points in the tree and wetland vegetated areas to 90 feet, and fine grading the area to direct drainage to the closest downstream drainage swales. This option would result in the loss of some existing wetland habitat but would not affect the extent of available riparian habitat. Excess fill is utilized to raise low points along the levee access road to 100 feet (see the Levee Road Profile, Plate 3) thus providing the same level of flood protection to the adjacent orchards currently provided by the existing interior levee. This option would require approximately 17,000 cubic yards of earthworks, of which approximately 5,000 cubic yards would be used to raise the levee road.

Gravel Pit Trap Removal Alternative 1 - Connect to Sacramento River at 84'

This alternative for eliminating the gravel fish trap represents the minimum earthwork grading option. Plate 4 illustrates elements of this option. This option does not provide for treatment of adjacent degraded flood plain areas however, it does preserve a significant area of riparian and wetland habitat within the gravel pit. This alternative would require approximately 11,000 cubic yards of earth works.

<u>Gravel Pit Trap Removal Alternative 2 - Fill and Connect to Floodplain at 87'</u>

This alternative for eliminating the gravel fish trap includes elements of filling the gravel pit and treating approximately 6 acres of the adjacent flood plain to improve riparian habitat. Plate 5 illustrates elements of this option. This alternative would involve filling the upstream drainage swale features up to 1-foot depths for a distance of approximately 300 feet up stream of the gravel pit. This grading could be accomplished by pushing material up the swales from the pond and would cause minimal impacts to existing mature trees adjacent to the swales. This alternative would preserve a significant area of riparian habitat within the gravel pit and would require approximately 42,000 cubic yards of earth works.

<u>Gravel Pit Trap Removal Alternative 3 - Fill and Connect to Floodplain at 90'</u>

This alternative for eliminating the gravel fish trap includes elements of filling the gravel pit and treating approximately 13 acres of the adjacent flood plain to improve riparian habitat. Plate 6 illustrates elements of this option. This option represents the maximum elevation for gravel pit filling to avoid significant disturbance to vegetation adjacent to the upstream drainage swales. In addition, any surfaces created by filling above this elevation would probably not be suitable for riparian habitat restoration. This alternative would involve filling the upstream drainage swales from 1-3 feet for a distance of approximately 500-600 feet up stream of the gravel pit. This grading could be accomplished by pushing material up the swales from the pond and would cause minimal impacts to existing mature trees adjacent to the swales. This alternative would eliminate all existing wetland habitat and the majority of riparian habitat within the gravel pit and would require approximately 87,000 cubic yards of earth works.

CONCLUSIONS AND RECOMMENDATIONS

Evaluation of the site topography has identified two main fish trap features within the La Barranca Unit of the U.S. Fish and Wildlife Service's Sacramento River National Wildlife Refuge. These features have been described in detail above and consist of an interior fish trap and an abandoned gravel pit. Fine sediment within the gravel pit was also mapped and quantified. These sediments provide a source for soil augmentation of coarse alluvial soils to aid riparian restoration at the site. The fine sediment and earth works volumes for the various grading options and alternatives are summarized in Table 1 below.

The interior fish trap strands fish caught within it when interior water surface elevations recede below approximately 94 feet. Filling this feature is constrained by the thalweg elevation of the closest down stream drainage swale. Grading of this feature to a minimum of 89 feet will be required to assure positive drainage. One option for eliminating this fish trap has been presented. Options involving grading to lower elevations and directing drainage further west toward the Sacramento River were not examined due to the extensive earthworks that would be required.

The gravel pit strands fish water when the gravel pit water surface elevations fall below approximately 89 feet. Filling the gravel pit is constrained by the thalweg elevations of the upstream drainage swales. In order to avoid extensive damage to existing riparian vegetation to the north of the gravel pit, avoid creating additional fish traps within the upstream swales, and assure appropriate topography for riparian restoration, this feature can only be filled to a maximum of approximately 90 feet. Three alternatives addressing a range of grading options for eliminating this fish trap and providing for 0-13 acres of adjacent flood plain restoration have been presented.

Table 1 – Site Feature and Grading Alternative Volumes

Feature/Alternative	Earthworks Volume (cubic yards)
Fines In Gravel Pit – To Full Depth	40,000
Fines In Gravel Pit – Top 2 Feet	7,000
Interior Fish Trap and Levee Removal	17,000*
Gravel Pit Trap Removal Alternative 1	11,000*
Gravel Pit Trap Removal Alternative 2	42,000*
Gravel Pit Trap Removal Alternative 3	87,000*

* Volumes are balanced cut/adjusted fill volumes using a 30% fill factor.

The grading options presented cover a range of finished grades that could be refined based on input from riparian and wetland vegetation studies at the site and corresponding topography and soils recommendations. Table 2 presents the areas of fill for the alternatives that would be available for riparian revegetation.

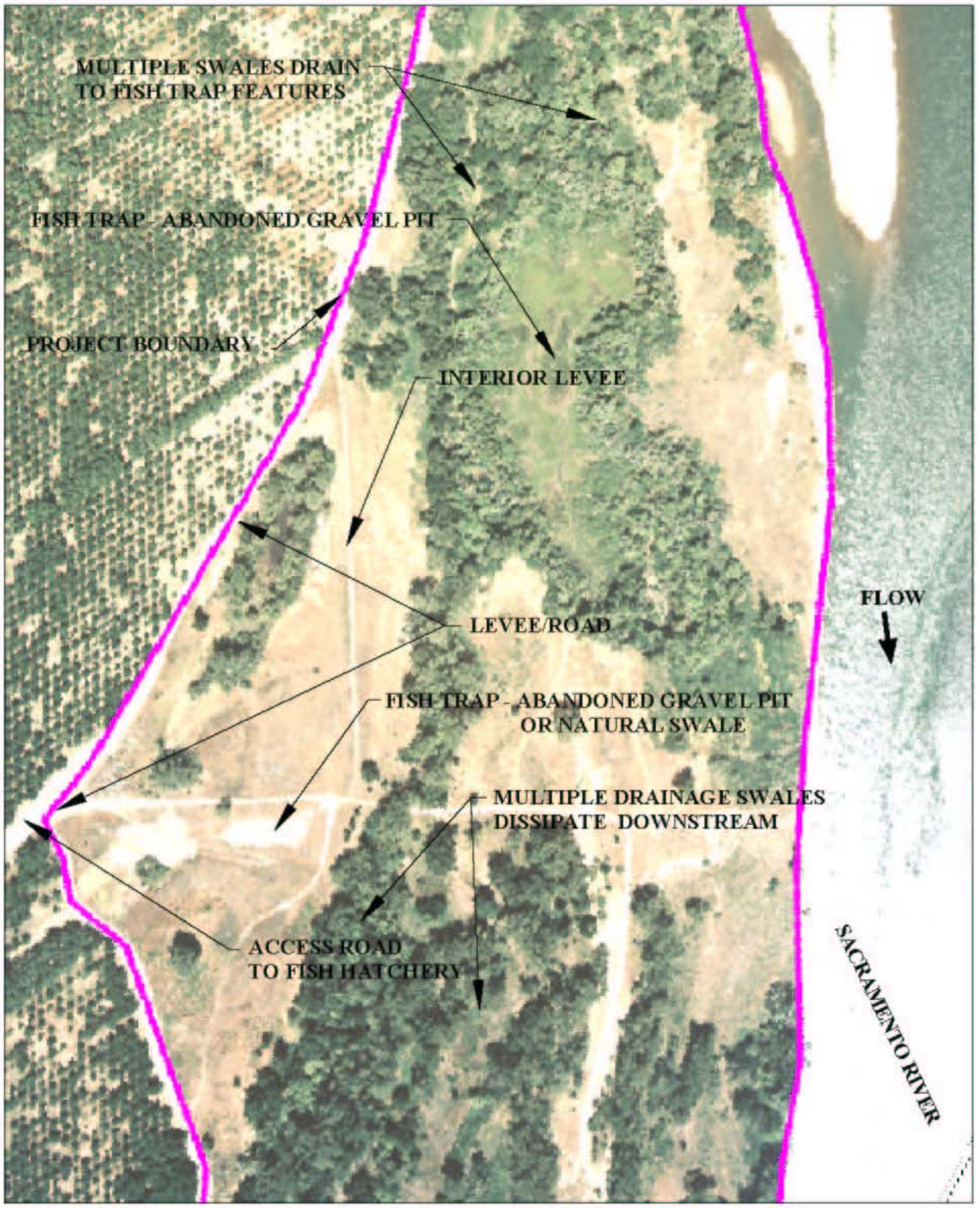
Table 2 – Areas of Potential Riparian Restoration

Alternative	Area at 90' Elevation and below (Acres)
Interior Fish Trap and Levee Removal	3.2
Gravel Pit Trap Removal Alternative 1	8.1
Gravel Pit Trap Removal Alternative 2	12.9
Gravel Pit Trap Removal Alternative 3	22.3

Following the determination of the appropriate level of restoration and financial commitment at the site, further design work may be warranted. To evaluate the risk of fish stranding (i.e. frequency of occurrence), hydraulic modeling of the project site and vicinity would be necessary. Such modeling would need to include closely spaced cross sections, particularly at and just upstream of the site, in order to evaluate the flow levels associated with flow entering the pit areas either through the various swales or from general floodplain surface overtopping. Once the flow magnitudes for such inflows were determined from modeling, the frequency of occurrence could be easily evaluated. Further, by examination of historic streamflow hydrographs would allow the delineation of the number of hours in various flood events that fish would be able to enter the site.

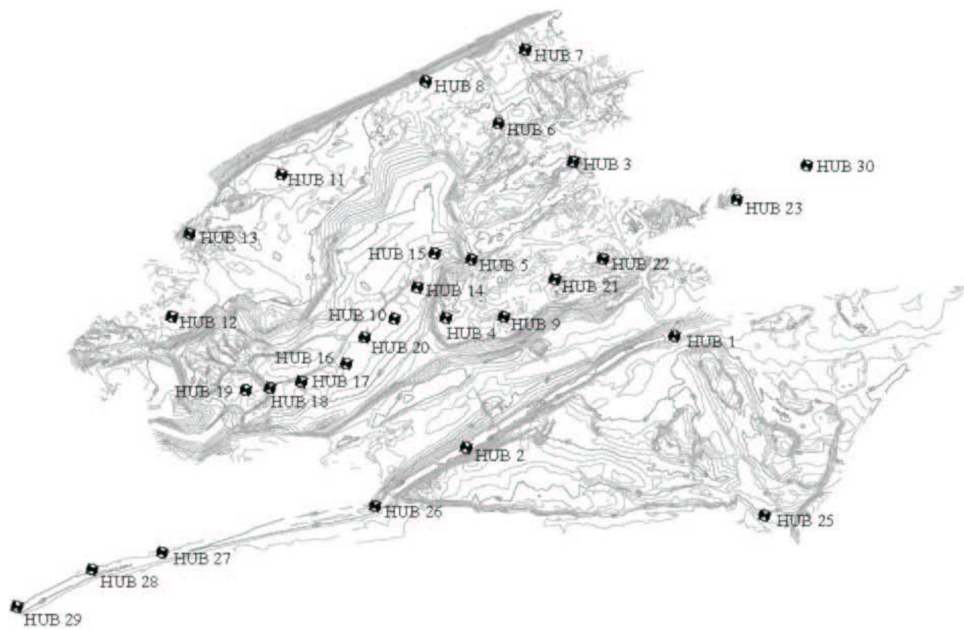
If elimination of fish traps and restoration of the site proceeds, additional topographic survey data and engineering characterization of the site soils may be warranted. Furthermore, final design work will require the integration of professional input from wetland and riparian botanists and fisheries and wildlife specialists. Grading operations are the most costly elements in performing restoration of this nature and the information presented in this report provides the basis for making solid estimates of the range of costs for performing such operations at the site.

LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)



LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5) SACRAMENTO RIVER NATIONAL WILDLIFE REFUGE U.S. FISH AND WILDLIFE SERVICE TEHAMA COUNTY, CALIFORNIA	GMA GRAHAM MATTHEWS & ASSOCIATES Hydrology · Geomorphology · Stream Restoration P.O. Box 1516 Weaverville, CA 96093-1516 (530) 623-5327 ph (530) 623-5328 fax wvgm@snowcrest.net	~ N	SCALE 0 300	FIGURE 1

LA BARRANCA UNIT RESTORATION PROJECT
TOPOGRAPHIC SURVEY CONTROL



Survey Control Coordinates*

Control Point	Northing	Easting	Elevation
HUB 1	5000.00	5000.00	100.00
HUB 2	5644.06	5000.00	100.23
HUB 3	5018.13	5549.86	97.06
HUB 4	5525.44	5338.34	94.32
HUB 5	5388.41	5445.72	91.12
HUB 6	5149.23	5737.51	92.93
HUB 7	4988.77	5880.96	93.61
HUB 8	5268.63	5933.04	93.33
HUB 9	5385.04	5265.78	93.62
HUB 10	5650.33	5402.15	82.71
HUB 11	5735.86	5894.79	96.91
HUB 12	6182.87	5693.71	97.50
HUB 13	6033.08	5870.25	94.23
HUB 14	5555.14	5448.84	82.22
HUB 15	5468.95	5508.00	82.69

Control Point	Northing	Easting	Elevation
HUB 16	5824.19	5356.36	82.16
HUB 17	5954.77	5370.70	82.71
HUB 18	6038.56	5396.44	81.70
HUB 19	6099.65	5422.49	82.40
HUB 20	5746.03	5395.42	82.25
HUB 21	5214.08	5290.65	91.91
HUB 22	5072.20	5277.94	93.90
HUB 23	4674.95	5247.31	94.50
HUB 25	5014.90	4452.97	95.61
HUB 26	5938.64	4976.52	101.92
HUB 27	6509.95	5139.42	98.80
HUB 28	6699.94	5188.80	99.49
HUB 29	6928.80	5195.87	99.28
HUB 30	4461.82	5240.16	95.22

*** Surveys based on arbitrary datum set at Hub 1.**

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LA BARRANCA UNIT RESTORATION PROJECT
SURVEY COVERAGE AND POINT DENSITY

Survey Point Density Legend

Point Density < 50 Feet, Average ~ 10 Feet

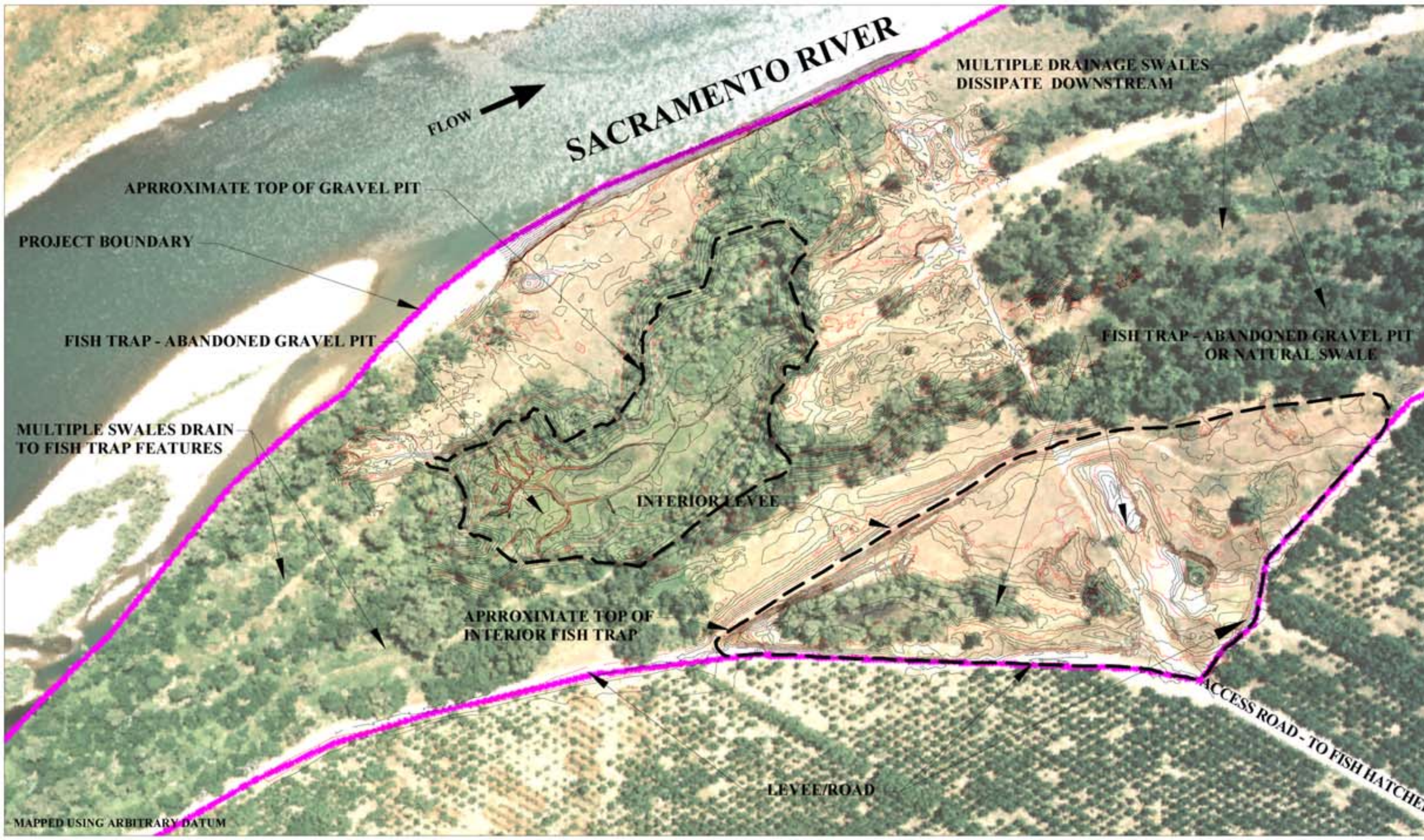
Point Density > 50 Feet, Average ~ 150 Feet

Point Density > 100 Feet, Average ~ 200 Feet

NO SURVEY DATA COLLECTED

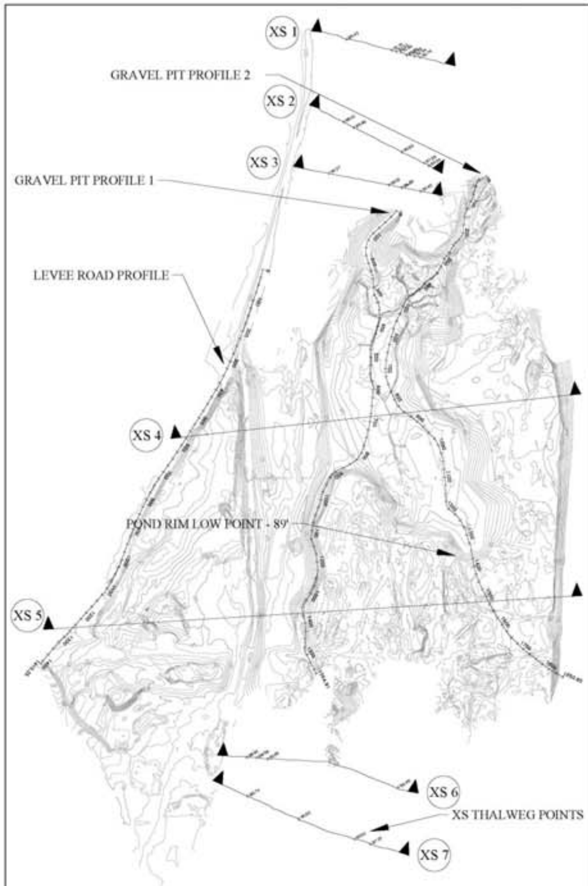
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5) SACRAMENTO RIVER NATIONAL WILDLIFE REFUGE U.S. FISH AND WILDLIFE SERVICE TEHAMA COUNTY, CALIFORNIA	GMA GRAHAM MATTHEWS & ASSOCIATES Hydrology · Geomorphology · Stream Restoration P.O. Box 1516 Weaverville, CA 96093-1516 (530) 623-5327 ph (530) 623-5328 fax wvgm@snowcrest.net	~ N	SCALE 0 400	FIGURE 3

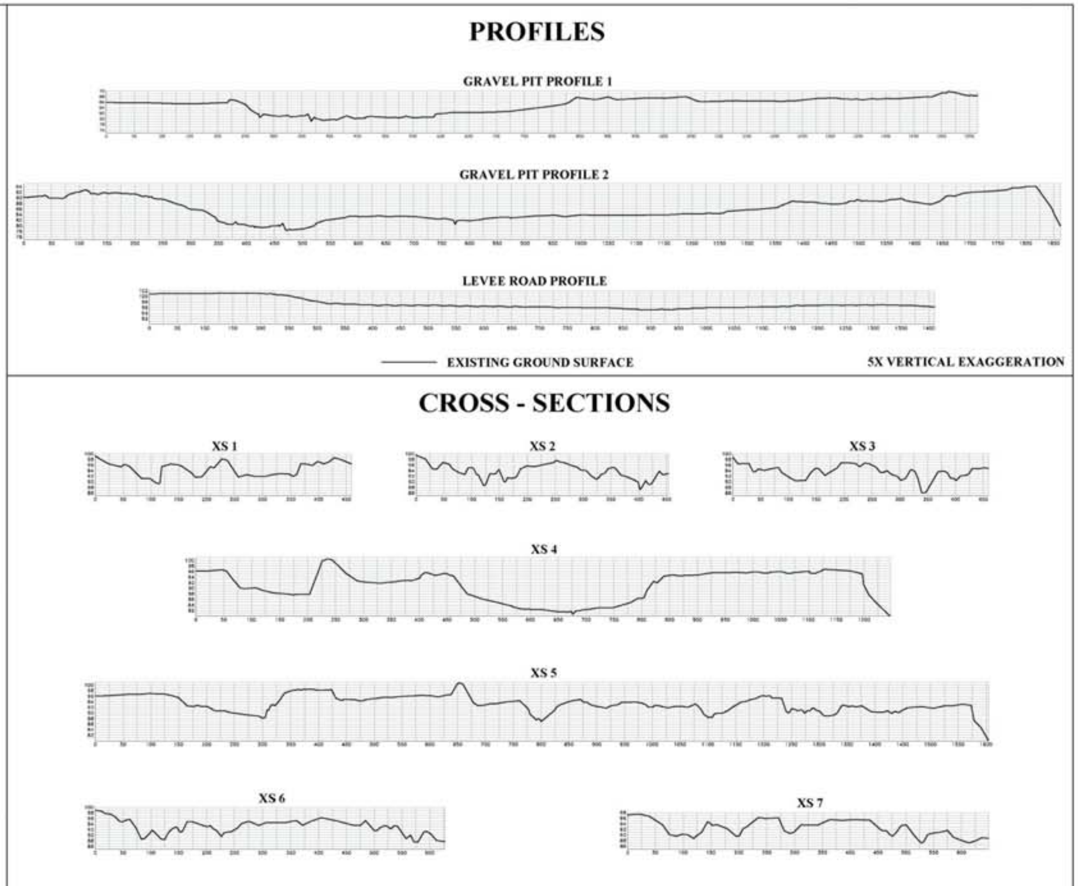
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
EXISTING GROUND TOPOGRAPHY AND SITE FEATURES



DESIGNED BY		DATE	REV. DATE	PREPARED FOR				SCALE	SHEET
PREPARED BY	WRN	5/01		SACRAMENTO RIVER PARTNERS 539 FLUME STREET CHICO, CA 95928 (530) 894-6775	LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5) SACRAMENTO RIVER NATIONAL WILDLIFE REFUGE, U.S. FISH AND WILDLIFE SERVICE TEHAMA COUNTY, CALIFORNIA	GMA GRAHAM MATTHEWS & ASSOCIATES Hydrology · Geomorphology · Stream Restoration	~N	FEET	1/6

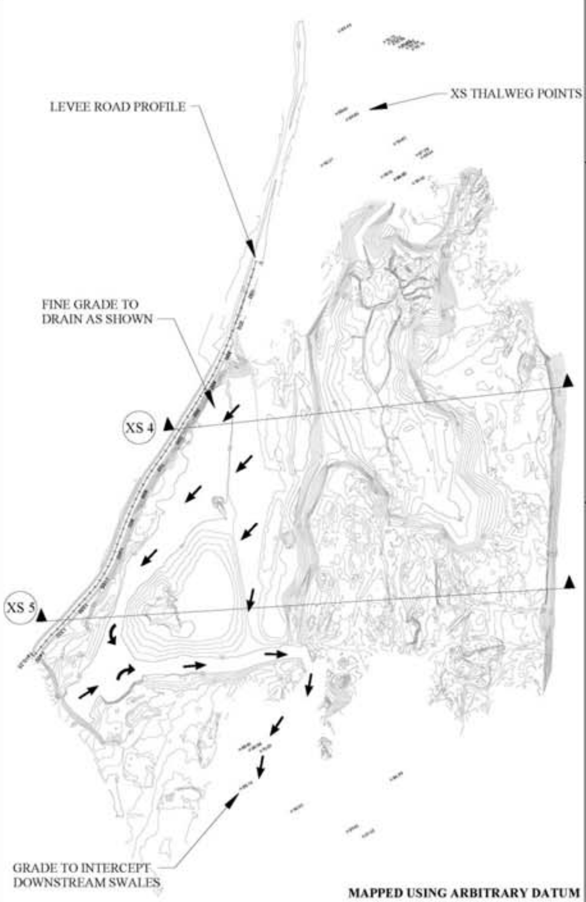
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
EXISTING TOPOGRAPHY, PROFILES AND CROSS-SECTIONS



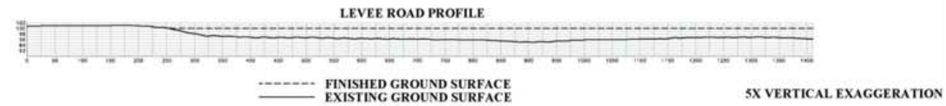


DESIGNED BY		DATE	REV. DATE	PREPARED FOR				
PREPARED BY	WRN	5/01		SACRAMENTO RIVER PARTNERS 539 FLUME STREET CHICO, CA 95928 (530) 894-6775	LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5) SACRAMENTO RIVER NATIONAL WILDLIFE REFUGE, U.S. FISH AND WILDLIFE SERVICE TEHAMA COUNTY, CALIFORNIA	GMA GRAHAM MATTHEWS & ASSOCIATES Hydrology · Geomorphology · Stream Restoration	SCALE FEET	SHEET 2/6

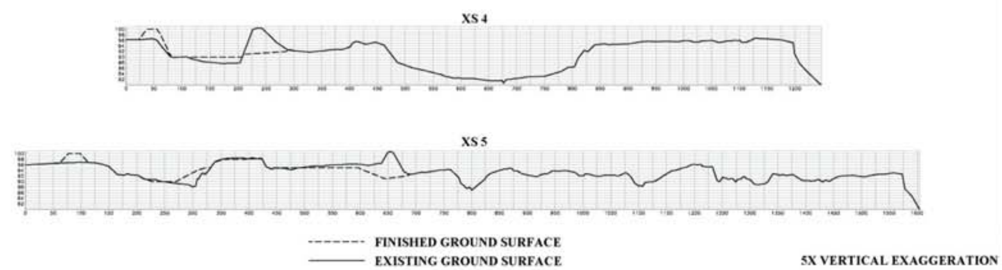
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
INTERIOR LEVEE AND FISH TRAP REMOVAL



PROFILES



CROSS - SECTIONS



NOTES

REDUCE INTERIOR LEVEE TO ~ 93'
RAISE LEVEE ACCESS ROAD TO 100'
GRADE INTERIOR FISH TRAPS TO DRAIN TO DOWNSTREAM SWALES AT ~ 90'

ESTIMATED EARTHWORKS:

APPROXIMATELY BALANCES USING 30% FILL FACTOR

CUT/FILL ~ 17,000 CUBIC YARDS

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TEHAMA COUNTY, CALIFORNIA

GMA
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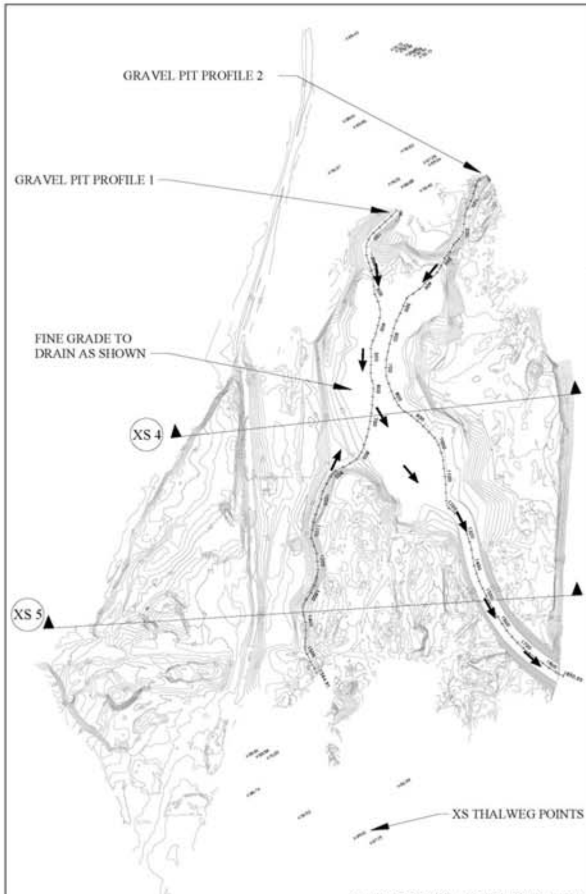
~N

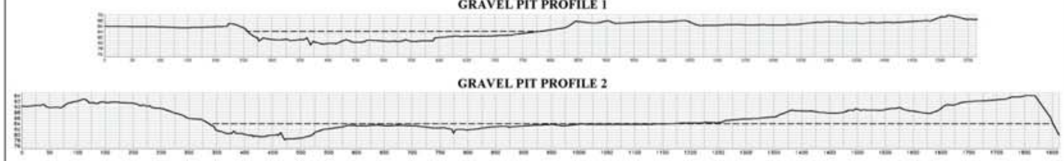
SCALE
FEET

SHEET 3/6

LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
GRAVEL PIT TRAP REMOVAL ALTERNATIVE 1 - CONNECT TO SACRAMENTO RIVER AT 84'



PROFILES



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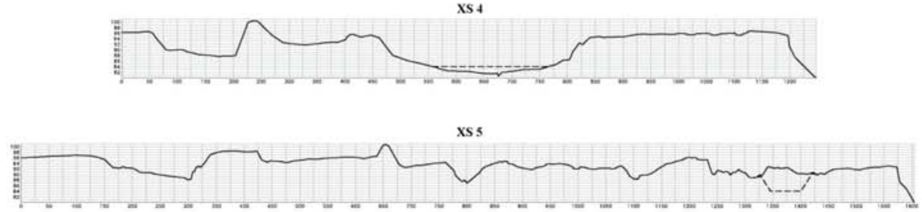

NOTES

CONNECT GRAVEL PIT TO SACRAMENTO RIVER AT ~ 84'
FILL AND GRADE GRAVEL PIT TO DRAIN AT ~ 84'

ESTIMATED EARTHWORKS:

APPROXIMATELY BALANCES USING 30% FILL FACTOR

CUT/FILL ~ 11,000 CUBIC YARDS

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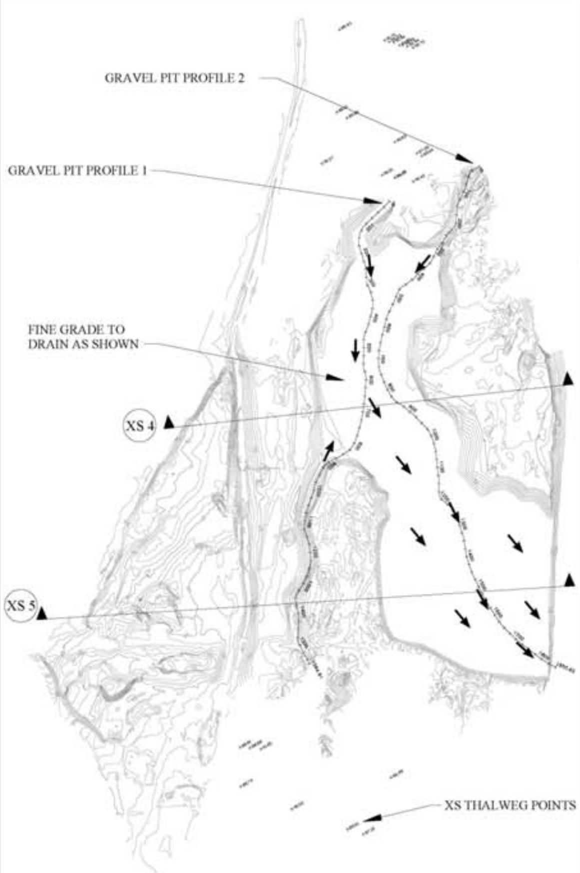
N

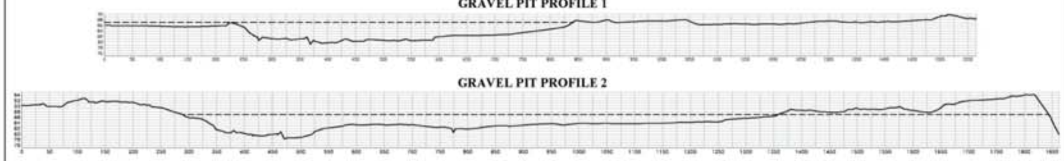
SCALE
FEET

SHEET 4/6

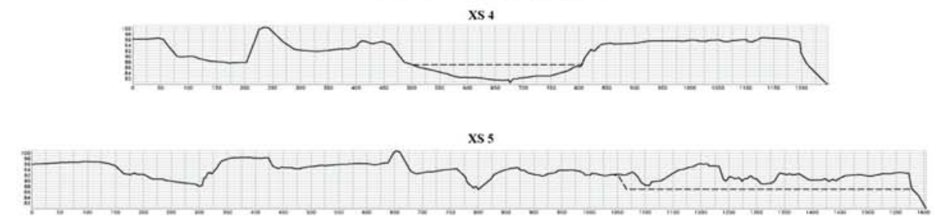
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
GRAVEL PIT TRAP REMOVAL ALTERNATIVE 2 - FILL AND CONNECT TO FLOOD PLAIN AT 87'



PROFILES



CROSS - SECTIONS



NOTES

FILL GRAVEL PIT TO ~ 87'
LOWER FLOOD PLAIN TO ~ 87' TO ALLOW GRAVEL PIT TO DRAIN TO SACRAMENTO RIVER

ESTIMATED EARTHWORKS:

APPROXIMATELY BALANCES USING 30% FILL FACTOR

CUT/FILL ~ 42,000 CUBIC YARDS

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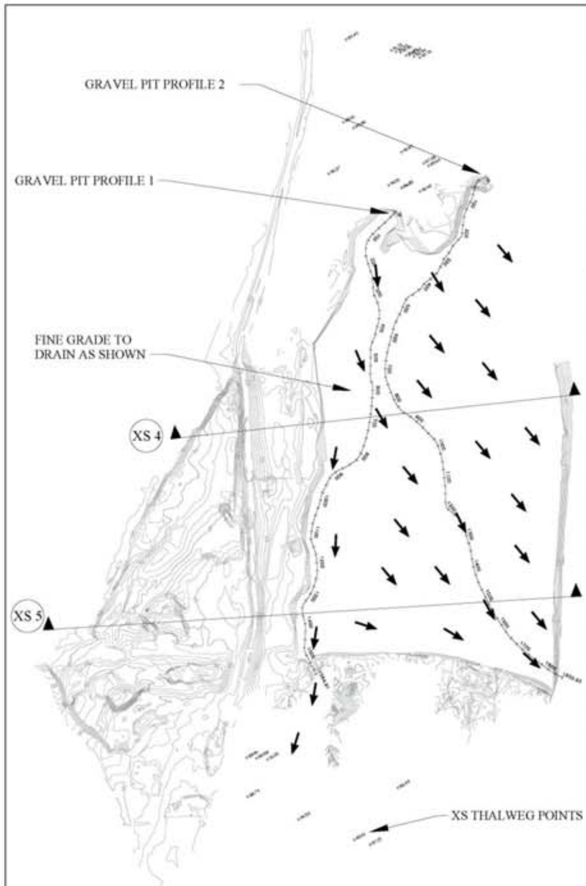
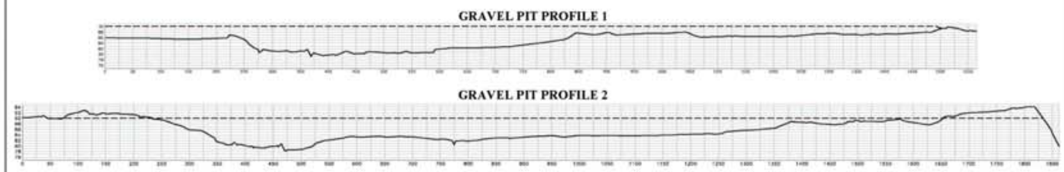
LA BARRANCA UNIT RESTORATION PROJECT (RIVER MILE 238-239.5)
GRAVEL PIT TRAP REMOVAL ALTERNATIVE 3 - FILL AND CONNECT TO FLOOD PLAIN AT 90'



MAPPED USING ARBITRARY DATUM

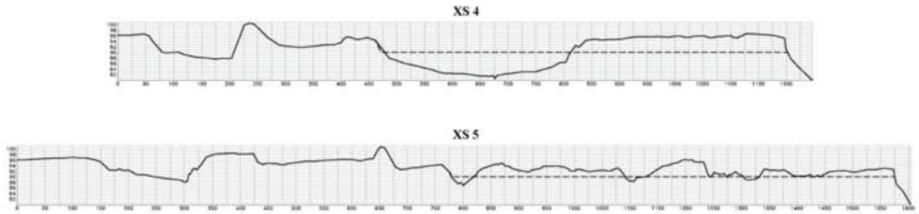
PROFILES



- - - - - - FINISHED GROUND SURFACE
———— EXISTING GROUND SURFACE

5X VERTICAL EXAGGERATION

CROSS - SECTIONS



- - - - - - FINISHED GROUND SURFACE
———— EXISTING GROUND SURFACE

5X VERTICAL EXAGGERATION

NOTES

FILL GRAVEL PIT TO ~ 90'
LOWER FLOOD PLAIN TO ~ 90' TO ALLOW GRAVEL PIT
TO DRAIN TO SACRAMENTO RIVER AND DOWNSTREAM SWALES

ESTIMATED EARTHWORKS:

APPROXIMATELY BALANCES USING 30% FILL FACTOR

CUT/FILL ~ 87,000 CUBIC YARDS

DESIGNED BY		DATE	REV. DATE	PREPARED FOR				SCALE	SHEET
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Appendix III

Bird Species List from 2000 and 2001 PRBO and USFWS Surveys at the La Barranca Unit

La Barranca Bird Species List 2001

Scientific Name	Common Name	Abbreviation	Source
Aphelocoma californica	Western scrub-jay	WSJA	PRBO, 2000
Archilochus alexandri	Black-chinned hummingbird	BCHU	PRBO, 2000
Baeolophus inornatus	Oak Titmouse	OATI	PRBO, 2000
Calypte anna	Anna's hummingbird	ANHU	PRBO, 2000
Carduelis psaltria	Lesser goldfinch	LEGO	PRBO, 2000
Carduelis tristis	American goldfinch	AMGO	PRBO, 2000
Carpodacus mexicanus	House Finch	HOFI	PRBO, 2000
Contopus sordidulus	Western wood-pewee	WWPE	PRBO, 2000
Dendroica petechia	Yellow warbler	YEWA	PRBO, 2000
Geothlypis trichas	Common yellowthroat	COYE	PRBO, 2000
Icterus galbula	Bullock's oriole	BUOR	PRBO, 2000
Molothurus ater	Brown-headed coebird	BHCO	PRBO, 2000
Myiarchus mexicanus	Ash-throated flycatcher	ATFL	PRBO, 2000
Passerina amoena	Lazuli bunting	LABU	PRBO, 2000
Pheucticus melanocephalus	Black-headed grosbeak	BHGR	PRBO, 2000
Picoides pubescens	Downy woodpecker	DOWO	PRBO, 2000
Pipilo crissalis	California towhee	CATO	PRBO, 2000
Psaltriparus minimus	Bushtit	BUSH	PRBO, 2000
Sitta carolinensis	White-breasted nuthatch	WBNU	PRBO, 2000
Sturnus vulgaris	European starling	EUST	PRBO, 2000
Tachycineta bicolor	Tree swallow	TRSW	PRBO, 2000
Troglodytes aedon	House wren	HOWR	PRBO, 2000
Turdus migratorius	American robin	AMRO	PRBO, 2000
Tyannus verticalis	Western kingbird	WEKI	PRBO, 2000
Wilsonia pusilla	Wilson's warbler	WIWA	PRBO, 2000
Zenaida macroura	Mourning dove	MODO	PRBO, 2000
Calidris minutilla	Least sandpiper	LESA	USFWS, 2000
Callipepla californica	California quail	CAQU	USFWS, 2000
Charadrius vociferus	Killdeer	KILL	USFWS, 2000
Circus cyaneus	Northern harrier	NOHA	USFWS, 2000
Junco hyemalis	Oregon junco	ORJU	USFWS, 2000
Pica nuttalli	Yellow-billed magpie	YBMA	USFWS, 2000
Sayornis nigricans	Black pheobe	BLPH	USFWS, 2000
Scolopacidae spp.	Sandpiper spp.	SAND	USFWS, 2000
Sialia mexicana	Western bluebird	WEBL	USFWS, 2000
Zonotrichia leucophrys	White-crowned sparrow	WCSP	USFWS, 2000

PRBO. 2000. Habitat Associations and Species Composition of Riparian Bird Communities in the Sacramento Valley and Lassen Foothill Tributaries: A Report of the 2000 Field Season.

USFWS. 2000. Unpublished Avian Survey Completed at the La Barranca Unit. Joe Silvera and Jim Snowden. 11/15/2000.

Appendix IV

USFWS. 2001. 2001 La Barranca Floodplain Restoration Feasibility Study – Supplemental Biology Survey. US Fish and Wildlife Service, Red Bluff Fish and Wildlife Office.

2001 La Barranca Floodplain Restoration Feasibility Study-Supplemental Biology Survey

US Fish and Wildlife Service
Red Bluff Fish and Wildlife Office

Wildlife and Fisheries Observations

Methods: On 27 March, 2001, two Red Bluff Fish and Wildlife Office biologists performed a foot survey of the water margins of two isolated ponds and an oxbow in the floodplain of the La Barranca site. The purpose of the survey was to record the presence of fish and wildlife without the use of specialized sampling gear. The surface area of the northern most pond (analyzed by hydrologist, Graham Matthews) was estimated to be one acre. The surface area of the southernmost pond was roughly one acre and the oxbow was two to three acres. There was no apparent connectivity to the Sacramento River in any of theses water bodies, and the oxbow would be the first area to reconnect to the river if river stage levels rose.

Results: Water temperatures were estimated to be between 60 and 70 degrees Fahrenheit in the two ponds and 50 to 60 degrees Fahrenheit in the oxbow. Water clarity was 6 –8 inches in all three water bodies.

In the first pond we observed mosquitofish (G*ambusia affinis*) and another species, possibly hitch (minnow family). A male treefrog (*Hyla regilla*) was captured, identified and released. A beaver (*Castor canadensis*) lodge was present and racoon (*Procyon lotor*) tracks were seen. The substrate was thick mud.

In the second pond, the aquatic vegetation was minimal. The bottom was mud. Bluegill (*Lepomis macrochirus*) were abundant. At least six Northwestern pond turtle (*Clemmys marmorata marmorata*), a state species of special concern, were observed basking on a partially submerged log.

In the oxbow, we observed thick emergent aquatic vegetation covering the water surface. The oxbow had a mud substrate. Water clarity was greater than 8 inches below the canopy of aquatic vegetation provided the mud was not disturbed. We observed a beaver lodge and heard juvenile bullfrogs (*Rana catesbeinana*). Live and dead crayfish (*decapoda* spp.) were abundant. Several Western pond turtles basked in the sun on partially submerged logs. Egrets (*Bubulcus ibis*) were also present in the oxbow margins.

Other species observed in the area, but not directly associated with the ponds and oxbow were pheasant (*Phasianus colchicus*), redwing black bird (*Agelaius phoeniceus*), quail (*Callipepla californica*), osprey (*Pandion haliaetus*), blue heron (*Ardea herodias*), turkey vulture (*Cathartes aura),* kite (*Elanus caeruleus*), Columbia Black-tail deer (*Odocoileus hemionus columbianus),* turkeys (*Meleagris gallopavo*), red tail hawk (*Buteo jamaicensis*), fence lizard (*Sceloporus occidentalis*), and Western gray squirrel (*Sciurus griseus*).

Discussion: This survey was cursory and meant to supplement the more detailed topographic analysis. Reportedly, gravel mining produced the two ponds at the study site. The oxbow is naturally occurring, but it may not function as it did due to water regulation by Shasta and Keswick Dams. The relative isolation of the ponds and oxbow from the Sacramento River at the La Barranca site may influence species presence.

The most abundant aquatic species observed in the ponds and oxbow were non-native bluegill and gambusia. Juvenile native fishes, such as Sacramento sucker (*Catastomis occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), chinook salmon (*Oncorhynchus tshawytcha*), and steelhead (*Oncorhynchus mykiss*), were not observed in the ponds and oxbow. The lack of native fishes in the ponds may be related to habitat availability and competition or predation from non-native species.

California native amphibians, such as red-legged frog (*Rana aurora*), and foothill yellow-legged frog (*Rana boylii*), and native reptiles, such as Northwestern pond turtle were not obsreved in the ponds or oxbow. These species are potential candidates for state or federal listing because of abundance declines (Jennings and Hayes 1994). Moyle (1973) claimed predation and competition from non-native bullfrog might have contributed to declines in native amphibians in the San Joaquin Valley. Juvenile bullfrogs were heard at the oxbow. Altered habitats that increase water temperatures or reduce stream flow, such as the ponds and oxbow, may favor non-native herpetofauna, such as bullfrog (Hayes and Jennings 1986).

Generally speaking, the higher the elevation of a pond within the floodplain and the less frequently that the water body reconnects to the river, then the less is the risk of fish entrapment. On the other hand, if unnaturally formed ponds reconnect to the mainstem during high water, but lack a drain when high water recedes, fish entrapment could be a problem. Therefore, fish entrapment is related to the elevation of a pond within the floodplain, the frequency that a pond reconnects to the river, and the existence of a drain to allow fish escapement. Since a detailed hydrologic or topographic analysis of the entire study site was not done, which could predict flood frequency and escape potential, we have no data to assess the risk of entrapment. The issue, however, warrants further study.

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Appendix V

Griggs, F.T. 2001 La Barranca Vegetation Survey
Plant Species List from 2001 Vegetation Surveys

Pg.	Scientific Name	Common Name	Range of Frequency Found			Elevation	Literature notes
			Forest/ woodland	Grassland/ savanna/ gravelbar	Wetlands open water		
125	*Acer negundo*	Box elder	3		2-4	<1800 m	Along streamsides and bottomlands
1227	*Aegilops spp.*	Goat grass		1			
682	*Aesculus californica*	California buckeye		X		<1700 m	Dry slopes, canyons, and borders of streams
1227	*Agrostis spp.*	Bent grass	1-2	1	X		Esp. temp. AM, Eurasia
1067	*Ailanthus altissima*	Tree of heaven	1-3			<1250 m	Disturbed urban areas and waste places
1230	*Aira spp.*	Hairgrass		2			
364	*Alnus rhombifolia*	White alder	1-2			100-2400m	Along permanent streams
170	*Aristolochia californica*	Pipevine	1-2	X	1	<700 m	Streamsides, forest, chaparral
204	*Artemisia douglasiana*	Mugwart	2	3-4	1	<2200 m	Shady places, often in drainages
1235	*Arundo donax*	Giant reed	2	1	1	25-1220 m	Disturbed sites
1236	*Avena fatua*	Wild oats		X	2	<500 m	Moist places, seeps, ditchbanks
214	*Bidens pilosa*	Beggar tick	2	X	X	Gen. <750 m	Disturbed sites
406	*Brassica nigra*	Black mustard		X	1-2	<1500 m	Fields, disturbed areas
215	*Brickellia spp.*	Sharab		1-3			
1182	*Brodiaea elegans*	Harvest brodiaea		1		0-2200 m	Grasslands, meadows, open woodlands
1242	*Bromus diandrus*	Ripgut	3-4	1	1	<2000 m	Open gen. Disturbed places, fields
1242	*Bromus hordeaceus*	Soft chess		2	X	<1000(2100) m	Open often disturbed places
1122	*Carex barbarae*	Santa Barbara sedge	2-3	3	1	<900 m	Seasonally wet places
1138	*Carex vulpinoidea*	Fox sedge			1	<1200 m	Wet places
475	*Caryophyllaceae spp.*	Pink family			1		
*74	*Catalpa speciosa*	Northern catalpa		X	X	100-200 ft.	
222	*Centaurea solstitialis*	Star thistle		2	4	<1300 m	Pastures, roadsides, disturbed grassland or woodland
978	*Cephalanthus occidentalis*	Buttonbush	2		1	3-1000 m	Lakes, stream edges
239	*Cirsum vulgare*	Bull thistle			2	<2300 m	Disturbed areas
914	*Clematis ligusticifolia*	Virgin's bower	1-2	1		<2400 m	Along streams, wet places
521	*Convovulus arvense*	Morning glory		X		Gen. <1500 m	Orchards, gardens
240	*Conyza canadensis*	Horseweed			1	Gen <2000 m	Waste ground
1248	*Cynodon dactylon*	Bermuda grass	4	3	1-2	<900 m	Disturbed sites
1138	*Cyperus spp.*	Nut sedge			1		
1070	*Datura stramonium*	Jimson weed		X	X	<1500 m	Sandy soils, open often disturbed areas

Pg.	Scientific Name	Common Name	Range of Frequency Found			Elevation	Literature notes
			Forest/ woodland	Grassland/ savanna/ gravelbar	Wetlands open water		
146	*Daucus carota*	Wild carrot	X	2	X	0-1200 m	Roadsides, disturbed places
1254	*Elymus glaucus*	Blue wildrye	2-3	1-3	1	<2500 m	Open areas, chaparral, woodlands, forests
1256	*Elymus multisetus*	Big squirreltail		2		<3200 m	Open sandy rocky areas
95	*Equisetum laevigatum*	Smooth scouring rush			X	<3000 m	Moist sandy or gravel areas
95	*Equisetum spp.*		1		1		
573	*Eremocarpus stigerus*	Dove weed		1		<1000 m	Dry open often disturbed areas
876	*Eriogonum nudum*	Naked buckwheat		X		<3800 m	Dry open places
860	*Eriogonum spp.*	Buckwheat		2-3			Dry open places
672	*Erodium botrys*	Long-beaked storks bill		1		<1000 m	Dry open or disturbed sites
266	*Euthamia occidentalis*	Goldenrod	1			<2300 m	Ditches, marshes, streambanks, meadows
765	*Ficus carica*	Fig	2			<800 m	Moist disturbed areas, persisting near old habitations
148	*Foeniculum vulgare*	Fennel		1		0-350 m	Roadsides, waste places
776	*Fraxinus latifolia*	Oregon ash	1-3	1	X	<1700 m	Canyons, streambanks, woodlands
982	*Galium aparine*	Goose grass	3		1	30-1500 m	Grassy, half-shady places, weedy in gardens
270	*Gnaphalium spp.*	Cudweed			1		Worldwide
272	*Grindelia camporum*	Gumplant		X	X	<1400 m	Sandy or saline bottomlands, fields, roadsides
276	*Helenium bigelovii*	Bigelows sneezeweed	3		1	0-3000+ m	Wet meadows, marshes, and bogs
283	*Hemizonia kelloggii*	Tarweed		1		<700 m	Open areas
280	*Hemizonia spp.*	Tarplan, tarweed		1			Poor soils
286	*Heterotheca grandflourum*	Telegraphweed		1		<300 mm	Disturbed areas, dry streams, sand dunes
286	*Heterotheca oregonia*	Oregon golden-aster		1		<1000 m	Disturbed areas, dry streams, gravel bars
1266	*Hordeum murinum ssp. leporinum*	Foxtail barley		2		<1000 m	Moist gen. Disturbed sites
709	*Hypericum perforatum*	Klamath weed		1		<1500 m	Pastures, abandoned fields, disturbed places
709	*Juglans californica*	Black walnut	1-4			50-900 m	Slopes, canyons, valleys
709	*Juglans regia*	English walnut	1			<200 m	Persisting near abandoned habitations
1157	*Juncus spp.*	Rush			1		Worldwide esp. Northern hemesphere
1034	*Kickxia spuria*	Toad flax			1	0-1000 m	Disturbed, open places
296	*Lactuca serriola*	Prickly lettuce			X	<2000 m	Disturbed places
1267	*Leerisia oryzoides*	Rice cut-grass			2	<700 m	Marshes, streams, and ponds
429	*Lepidium latifolium*	White top pepperweed	1	2		<1900 m	Beaches, tidal shores, saline soils, roadsides

Pg.	Scientific Name	Common Name	Range of Frequency Found			Elevation	Literature notes
			Forest/ woodland	Grassland/ savanna/ gravelbar	Wetlands open water		
1270	*Leymus triticoides*	Creeping wildrye	3	2-3	X	<2300 m	Moist often saline meadows
1270	*Lolium multiflorum*	Annual ryegrass		X		<1000 m	Disturbed sites, abandoned fields
800	*Ludwigia peploides*	Yellow waterweed			4	<900 m	Ditches, streambanks, lake shores
622	*Lupinus spp.*	Lupine		2			
538	*Marah fabaceus*	Man-root		X		<1600 m	Streamsides, washes, shrubby and open areas
716	*Mentha pulegium*	Pennyroyal			1-2		Wet places, edge of water line
718	*Monardella spp.*	Monardella		X	X		
765	*Morus alba*	Mulberry	2				Disturbed areas, moist soil, streambanks
1274	*Muhlenbergia rigens*	Deergrass		2		<2150 m	Sandy to gravelly places, canyons, stream bottoms
1050	*Penstemon spp.*	Beardtongue		X			
1281	*Phalaris arundenaceae*	Reed canarygrass			X	<1600 m	Wet streambanks, moist areas, grassland, woodland
1281	*Phalaris spp.*		X				Temp. North America and Eurasia
819	*Phytolacca americana*	Pokeweed	2			<1000 m	Disturbed areas, gardens roadsides
120	*Pinus Sabiniana*	Grey pine		2		150-1500 m	Infertil soils in mixed conifer and hardwood forests
821	*Plantago lanceolata*	English plaintain		2		<1600 m	Weed of waste places, lawns and roadsides
820	*Plantago spp.*	Plantain			X		Worldwide
822	*Plantanus racemosa*	Sycamore	2	X	X	<2000 m	Streamsides, canyons
1218	*Poaceae spp.*	Annual grasses	4				
888	*Polygonum amphibium*	Water smartweed			X	<3000 m	Shallow lakes, streams, shores
886	*Polygonum spp.*	Smart weed	2		1		Worldwide esp. Northern hemesphere
990	*Populus fremontii*	Fremont cottonwood	2-4	1	2	<2000 m	Alluvial bottomlands, streamsides
662	*Quercus lobata*	Valley oak	1-4	1	3	<1700 m	Slopes, valleys, savannah
974	*Rubus discolor*	Himalayan blackberry	1-3	X	1	<1600 m	Disturbed moist areas, roadsides, fenceroads
975	*Rubus ursinus*	Native blackberry		2		<1500 m	Gen. Moist places, shrubland, streamsides
894	*Rumex crispus*	Curly dock		1-2	1	<2500 m	Disturbed places
997	*Salix Exigua*	Sandbar willow	3		1-2	<2700 m	Streamsides, marshes, wet ditches
997	*Salix Exigua*	Gravelbar willow		2		<2700 m	Streamsides, marshes, wet ditches
997	*Salix gooddingii*	Black willow	2-4		2	<500 m	Streamsides, marshes, seepage areas, washes, meadows
997	*Salix lasiolepis*	Arroyo Willow	3		2	<2800 m	Shores, marshes, meadows, springs, bluffs

Pg.	Scientific Name	Common Name	Range of Frequency Found			Elevation	Literature notes
			Forest/ woodland	Grassland/ savanna/ gravelbar	Wetlands open water		
998	*Salix lutia*	Yellow willow	3		2	900-3100 m	Creek margins, wet meadows
474	*Sambucus mexicana*	Elderberry	1-3	X		<3000 m	Streambanks, open places in forest
491	*Silene gallica*	Grass pink		2	1	<1000 m	Fields, disturbed areas
342	*Silybum marianum*	Milk thistle			2	<500 m	Roadsides, pastures, waste areas
1074	*Solanum spp.*	Nightshade	3				
1296	*Sorghum halepense*	Johnson grass	2	2		<800 m	Disturbed areas, ditchbanks, roadsides
1299	*Taeniatherum caput-medusae*	Medusahead		3	4		
1080	*Tamarix spp.*	Tamarisk	1	X			
166	*Torilis arvensis*			X	1	40-1600 m	Disturbed places
136	*Toxicodendron diversilobum*	Poison oak	1			<1650 m	Canyons, slopes chaparral, oak woodland
652	*Trifolium hirtum*	Rose clover		2-4	3	<2060 m	Disturbed areas, roadsides
1309	*Typha spp.*	Cattail	2		3		Worldwide
1083	*Urtica dioica*	Stinging nettle	2		X	<3000 m	Streambanks, margins of deciduous woodland, moist waste places
1064	*Vebascum thapsus*	Woolly mullein	X			<2200 m	Disturbed areas
1064	*Verbascum blattaria*	Moth mullien			1	<1600 m	Disturbed areas
654	*Vicia spp.*	Vetch	2	2-3			North Americaa, Eurasia
169	*Vinca major*	Greater periwinkle	1			2-200 m	Sheltered places, esp. along streams
1098	*Vitis californica*	California wild grapes	2		1-4	<1000 m	Streamsides, springs, canyons
359	*Xanthium strumarium*	Cocklebur			2		Worldwide

A frequency range of 1 indicates rare/ infrequent; 2 indicates frequent; 3 indicates common; 4 indicates abundant; X indicates species is present but the frequency was not noted.

*Pg. # derived from " Manual of the Vascular Plants of Butte County, California", Vernon H Oswald

All other Pg. derived from " The Jepson Manual Higher Plants of California", James C. Hickman

Appendix VI

Control Measure and Life History Information on Targeted Non-Native Plant Species.

CONTROL METHODS FOR NON-NATIVE TREES

	Salt Cedar (*Tamarix spp.*)	Giant Reed (*Arundo donax*)	Tree of Heaven (*Ailanthus altissima.*)
Mechanical Control	• Hand-pulling: for small infestations of saplings <1 in. in diameter. • Root-cutting and bulldozing**:** effective, but costly and labor intensive. May cause extensive damage to soils and lead to resprouting. • Prescribed burn: Some success, but resprouts after fire. • Flooding**:** root crown must remain submerged for at least 3 months.	Mechanical control is not very effective. It may leave root fragments in soil. Vegetation removal methods include: • Prescribed burn • Heavy machinery (i.e. bulldozers) • Handcutting by chainsaw or brushcutter, hydro-axe, chipper • Biomass burning or removal by vehicle**.**	• Handcuttiing: removes above-ground mass. • Handpulling: for young seedlings large enough to grasp, but before seeds are produced. • Hand digging • Girdling: manually cut away bark and cambial tissue around trunk in spring when trees are actively growing. Known to resprout below girdle unless treated with herbicides. • Grazing • Chopping, mowing • Prescribed burning: flame thrower or weed burner device can be used as spot treatment to heat girdle the lower stems of small trees.
Chemical Control	Most effective for extensive infestations. Systemic herbicide is recommended: • Foliar spray • Cut-stump treatment • Basal bark treatments • Aerial sprays Imazapyr controlled levels of salt cedar up to 90%.	Systemic herbicide is recommended: • Foliar spray: Apply 2-5% solution of Rodeo applied post-flowering and pre-dormancy (Mid-August –early November)at a rate of 0.5-1L/hA. Recent preliminary comparison trials resulted in 100% control with foliar application during appropriate season • Cut-stem**:** Cut stems treated with concentrated herbicide within 1-2 minutes in order for tissue uptake. 5-50% control using this treatment. • Cut stalks and remove biomass. Wait till new plants grow to 1 m. tall to apply a foliar spray of herbicide solution. Better coverage with shorter and uniform-height plants, but it returns plants to growth phase and less root-kill.	• Foliar spray: Apply 2% solution of glyphosate to leaves and green stems (including sprouts and suckers) until thoroughly wet. Administer during mid-June to mid-September. • Basal Bark treatment: Apply herbicide in a 12' wide band around the entire circumference of the base with no "skips". Treatment is mostly used on trees > 6in. in diameter. Bigger trees must be treated with a 24" band. This method works best during late winter/early spring (mid-February to mid-April) and in summer when base of tree stem is free of snow, ice, or water. Lower herbicide concentration during the summer. Follow up foliar herbicide application to basal sprouts and root suckers. • Hack and squirt injection method: Cut downward-angled cuts around tree trunk with an ax. Within 1 minute, apply 1-2 mm of 100% concentration

	Salt Cedar (*Tamarix spp.*)	Giant Reed (*Arundo donax*)	Tree of Heaven (*Ailanthus altissima.*)
			triclopyr product (Garlon 3A). Make a cut for each inch of diameter plus one. Space 1-2 inches between cuts and do not put into a continuous line. Glyphosate is recommended, but field trials have shown consistently poor long-term control. Best results during summer. • Cut stump method: Apply herbicides to cut stump immediately after cutting (5-15 min.) to ensure uptake before trees seals cut area. Best results during growing season.
Biological Control	Biological control agents are still being tested.	No biological control agents have been introduced to control this weed.	Potential biocontrol may lie in several fungal pathogens.
Preferred Control Method	Application of Imazapyr.	Foliar application of 2-5% solution of Rodeo applied post-flowering and pre-dormancy (Mid-August –early November)at a rate of 0.5-1L/hA.	Basal bark treatment with glyphosate.

	Perennial Pepperweed (*Lepidium latifolium*)	Leafy Spurge (*Euphorbia esula L.*)
Mechanical Control	Mechanical treatment is not suitable for this weed because of the incapability to cut its creeping root system fine enough. Mowing needs to be very frequent with a very short stubble height. Use cattle, sheep and goats for grazing perennial pepperweed. Dredging or removing topsoil from infested area, but large amounts of soil must be removed and disposed of in a way that will not contaminate other areas.	Prescribed burn and herbicide application: Spray plants with 2, 4-D in the September, and burned the following spring (April). Another application of 2, 4-D in June and a burn should follow in October.[1]
Chemical Control	Use pre-emergent herbicides during April. Remove old material so rosettes are exposed to herbicides. Research has determined the most effective stage to apply systemic herbicides to perennial pepperweed is the flowerbud to early flowering stage. **Selective herbicides:** Chlorsulfuron at 1.5 oz./acre (Telar at 2 oz./acre with 0.1% silicone based or 0.25% nonionic surfactant) for the best long-term control for noncrop areas.[1] It has been proven most effective for single application control. However, soil activity (half-life between 4-6 weeks) and foliar activity may harm highly desirable perennial vegetation, especially in riparian areas. Metsulfuron methyl works as well as chlorsulfuron, but has not been studied in as much detail. It also has foliar and soil activity (half-life in soils can vary from 1-6 weeks). It can be mobile in high pH soils. Triclopyr and 2,4-D(3.8 lbs. a.e./gal) are herbicides also effective in removing above ground growth without harming grass species. 2,4-D has most effective control when wicked at 100% solution for successive years.	For top growth control, 2,4-D amine can be sprayed on foliage with a 25% solution (1 part 2,4-D in 4 parts water) twice a year.[1] Spray 33% solution of Roundup (3 parts water, 1 part Roundup) to provide 80-90% top control during mid-August and mid-September. To control seedlings, a follow up treatment of 25% solution of 2,4-D amine between mid-June and mid-July of the following year must be applied.[1] **For control among trees:** Apply 2,4-D at 1 lb./acre (1 qt./acre of a 4-pound-per-gallon concentrate) may be used to control leafy spurge among trees.[2] Glyphosate plus 2,4-D (Campaign or Land master BW), which is applied at the early set-set stage, can be applied 2-4 weeks earlier than glyphosate alone to obtain good control and decrease grass injury under trees.[2] Dichobenil (Norosac 10G) will suppress leafy spurge for about one season. Apply 6-8 lbs./acre of Dichobenil (60-80 lbs. Of Norosac 10G) before it emerges in early spring, either in late November or in early to mid-April. Studies have shown that Dichlobenil applied at 8 lbs./acre in

	Perennial Pepperweed (*Lepidium latifolium*)	Leafy Spurge (*Euphorbia esula L.*)
	Non-selective herbicides: Imazapyr (2 lbs./gal): has foliar and soil activity with a half-life in soils varying between 3-21 weeks, but does not appear to be mobile in the soil. Imazethapyr (2 lbs./gal): has foliar and soil activity with a half-life in soils of 60-90 days. In sensitive areas (ie. Riparian, wetland), glyphosate at 3 lbs. a.e./acre (0.75 gallon Rodeo pro/acre) following an early season mowing and/or disking has proven effective.[1] The repeated use of Sulfonylureas (chlorsulfuron and Metsulfuron methyl) and Imidazolinones may promote resistance.	November provided 80% suppression the following June, but control declined to 20% by September. Dichlobenil will prevent only leafy spurge emergence only and does not affect emerged plant.[2] **For control near water:** Apply Fosamine (Krenite S) at 6-8 lbs./acre (1.5-2 gallons/acre) during the true flower growth stage. For best results, apply when soil moisture is abundant and relative humidity is high. Apply glyphosate (Rodeo) at 0.75 lb./acre (1.5 pints/acre) to provide 80-90% control when applied from mid-July to mid September. Use a follow-up treatment of 2,4-D formulation labeled for use near water at 0.5-1 lb./acre (1-2 pints of a 4-pound-per-gallon concentrate) applied from June to mid-July to prevent seedling establishment.
Biological Control	No biological control agents have been introduced to control this weed.	There are 6 highly promising natural enemies (imported from Europe) of leafy spurge that are being considered by the U.S. Department of Agriculture: These include a stem and root-boring beetle (*Oberea erythrocephala*), four root-mining flea beetles (*Apthona* spp.) and a shoot-tip gall midge (*Spurgia esulae*).[3]
Preferred Control Method	Mow during pre-flowering stage and then spray with glyphosate or 2,4-D after shoots emerge.	Prescribed burn and 2,4-D application.

	Johnson Grass (*Sorghum halepense*)	Yellow Starthistle (*Centaurea solstitialis*)
Mechanical Control	Mechanical control of Johnson grass aims to prevent new rhizome production and must be implemented within the first month after shoot emergence. It is most effective when grass is about 36 cm tall.[1] Dessicate rhizomes by dragging rhizomes to surface with a sweep or spike-tooth tiller. Accelerate dessication by cutting rhizomes into fragments less than 5 cm long. Rhizomes dried to 20% of their original weight completely lose their regenerative ability. Pasturing over a period of several seasons is advocated as an effective method. Geese provide excellent control of Johnson grass, but require a high level of management. Intense grazing should occur when rhizome carbohydrate levels are low. Prescribed burn, but timing is crucial. Frequent mowing to reduce the number of flowering stalks and clipping seedlings less than 3 weeks old during the spring and fall. Plants arising from rhizomes require 2 clippings within the first 2 weeks of growth to insure death of the plant.[2]	Cultivate soil after the rainy season when soils are dry and before seeds are produced.[1] Mowing needs to be well-timed and used on plants with a high branching pattern. It is most effective when soil moisture is low and no irrigation or rainfall follows mowing.[1] Must be mowed in late spring or early flowering stage to be successful. [1] Let starthistle seed, but mow well before it is in full flower.[1] Grazing is effective in reducing starthistle seed production. Sheep, goats, or cattle eat it. Grazing should occur during the bolting stage, usually in May through June. Grazing stock should be returned to graze 1-3 times at about 2 week intervals. Burning is best performed at the end of the rainy season when flowers first appear. Revegetate with desirable plant species to compete with starthistle (ie. grasses). Mulching with grasses or of other organic materials (between 2.5 –5 inches thick) have provided reduction of starthistle, but requires a considerable amount of material.[3]
Chemical Control	Multiple applications of glyphosate (Roundup) or dalapon (Dowpon). Spray 1% solution of glyphosate before and after planting native vegetation.[2] Spray glyphosate when plants are actively growing, greater than 18 in tall and have reached the bloom-to-head stage of growth. Inflorescences should be removed to prevent dispersal of mature seeds.[2] Apply dalapon at either the late boot stage or early growth stage prior to blooming	Post-emergent herbicides: Clopyralid is effective at rates as low as 1.5 oz. a.e./acre. It is also effective on plants in the bolting and early spiny stage, but higher rates (4 oz. a.e./acre) are required. 2,4-D can provide acceptable control of yellow starthistle if it applied at the proper rate and time. Application rates of 0.5 to 0.75 lb a.i./acre will control small rosettes, and 1-2 lb. a.i./acre for larger rosettes or after bolting stage. Dicamba at rates as low as 0.25 lb a.i./acre is very effective at controlling small rosettes, about 1 to 1.5 inches across. Higher rates (0.5-0.75 lb. a.i./acre) are needed for larger plants. Triclopyr provides complete control of seedlings at 0.5 lb. a.i./acre. Larger plants require rates up to 1.5 lb. a.i./acre. Glyphosate controls starthistle at 1 lb. a.i./acre. A 1% solution is sufficient for spot treatment of small patches. It is also very

	Johnson Grass (*Sorghum halepense*)	Yellow Starthistle (*Centaurea solsititialis*)
		effective method (at 1-2 lb. a.i./acre) of controlling starthistle plants in the bolting, spiny, and early flowering stages. Pre-emergent herbicides: Chlorsulfuron and sulfometuron, registered for roadside and other non-crop uses, are effective when applied at 1 to 2 oz a.i./acre.[1] Atrazine can control starthistle at rates of 1-1.5 lb.a.i./acre if applied before seedlings emerge. May be use for post-emergent activity when an oil-based adjuvant is used.[2] Simazine is effective at rates of 1.5 lb a.i./acre or higher.[2]
Biological Control	No biological control agents have been introduced to control this weed.	4 natural enemies established in California as biological control agents: 3 weevils-*Bangasternus orientalis*, *Eustenopus villosus*, and *Larinus curtus*; and the gall fly, *Urophora sirunaseua*.[2]
Preferred Control Method	Multiple applications of 1% glyphosate when plants are actively growing, greater than 18 in tall and have reached the bloom-to-head stage of growth.	Mow in late spring or early flowering stage, before it is in full flower. Then apply glyphosate at 1-2 lb. a.i./acre as plants are bolting, spiny and early flowering stages.

	Pokeweed *(Phytolacca americana L.)*	Himalayan blackberry *(Rubus discolor)*
Mechanical Control	Vegetation removal methods include: • Hand pulling • Disking, and • Burning	Prescribed burning: Burning may be accomplished with pre-spraying herbicide to kill and dessicate plants. Best results if this method is followed by 1) a stump herbicide application, 2) subsequent burning to exhaust soil seed bank and underground food reserves, and/or 3) revegetation with a fast-growing native species. Hand pulling: Pull plants as they are large enough to grasp and before they produce seeds. Hand hoeing Chopping, cutting, or mowing: Requires several cuttings to exhaust underground reserves. If there can only be one cutting, best if timed when plants begin to flower. Reserve supply is nearly exhausted and new seeds are not produced.
Chemical Control	Spray plants until moist with 2, 4-D low-volatile ester at 1 qt. of 4-pound acid equivalent per 25 gallons of water. Controls plants if sprayed when 8-12 inches high. Apply glyphosate at 1.1 to 1.5 lbs. ae/A or at 0.75 lb. Ae/A in combination with 2, 4-D ester (1- 1 ½ pt/A) in late September or early October when plants are 8-24 inches tall but before frost. For spot treatment: apply glyphosate in a 2% solution.	Apply herbicides when plants are in full leaf and after seeds set. Time foliar spray so it coincides with the maximum rate of sugar movement to the root system (depends on whether plants are primarily 1st year canes or a combination of 1st and 2nd year canes). Late summer for 1st year canes and early fall before plants become dormant for combination of canes. Application methods: Basal bark treatment: concentrated forms of triclopyr can be applied to basal regions. Thoroughly cover a 6-12 inch basal section of stems with spray, but not to the point of runoff. Apply almost any time of year. Dormant stem and leaf treatment: 1% triclopyr ester solution in a 3% crop oil mixture can be applied to dormant leaves and stems in late fall and winter. Picloram: effective, but one application may not be sufficient. Application suppresses cane regrowth but stimulates the development of adventitious shoots.

	Pokeweed *(Phytolacca americana L.)*	**Himalayan blackberry** *(Rubus discolor)*
		Glyphosate: can provide good to excellent control if applied at 0.5-1.5% solution. Late summer or early fall treatments have better control than treatments before or during flowering stage. Spraying till plant is wet is essential. Burning or mowing 40-60 days after application increases control. Triclopyr in ester or amine formulation: A 0.75-1% solution of Triclopyr ester is the most effective formulation. Amine formulation is not as effective as the ester form in being absorbed into the foliage. The amine form provides good control when applied at a 1% solution. Application should be in mid summer. When temperatures are greater than 80°F, best to use amine formulation as ester is subject to vaporization. Dicamba: Dicamba or in combinaton with 2,4-D may be applied in late summer to get good control. 2,4-D: provides only fair control and will result in resprouting. Tebuthiuron (Spike): a non-selective urea herbicide that is used for total control of shrubs, trees, and other weeds. It can be applied in pellet form to the base of plant to provide long-term control.
Biological Control	No biological control agents have been introduced to control this weed.	No biological control agents have been introduced to control this weed.
Preferred Control Method	Apply glyphosate in combination with 2,4-D in late September or early October when plants are 8-24 inches tall.	Late summer or early fall treatment of glyphosate applied at a 0.5-1.5% solution. Mow 40-60 days after application.

	Bull thistle (*Cirsium vulgare)*	Bindweed (*Convulvus arvensis*)
Mechanical Control	Cultivation	Vegetation removal include: Tillage: has generally produced negative results, especially on seedlings. Control should be conducted within the first 3-4 weeks to prevent plants from surviving. After perrenial buds are formed, control is more difficult. Cultivation or hoeing: partially effective, but must be done every 2-3 weeks as soon as bindweed reaches 6 inches. Mowing: may encourage ground-hugging growth. Prescribed burning: alone not effective, but may be useful in combination with other methods May also plant native vegetation to shade out bindweed. Perennial grasses compete well with this plant because they grow early in the season and take advantage of the limited soil moisture. Black polyethylene mulch may control small patches of bindweed by reducing the amount of light it receives. Continuously destroying the above-ground biomass triggers the massive root system to use its reserves to send out new shoots. Do not allow the above-ground biomass to regenerate and feed root system.
Chemical Control	Best times to treat with herbicides in late fall or early spring when rosettes are present but before flowering stalks are initiated.	2,4-D is generally the most effective against bindweed, but glyphosate can provide some control.

	Bull thistle (*Cirsium vulgare)*	Bindweed (*Convulvus arvensis*)
	One properly timed treatment per year should prevent seed formation. Fall treatments should be made late enough to kill all rosettes germinated before winter.	For best control around woody species, apply glyphosate to the bindweed when it begins to bloom. Glyphosate applied in the fall when bindweed is actively growing is also effective.
	Foliar treatments for selective removal: 2,4-D: 1-1 ½ qt./A, plants become resistant as flower stalk is produced. Dicamba: 1 pt./A	Dicamba and glyphosate may be applied at the flowering stage. Addition of Dicamba gives treatment some soil residual activities that helps control new seedlings, but may damage other plants.
	Metsulfuron: ¼ to ½ oz./A Triclopyr + 2,4-D: 2qt./A where woody species are present. Imazapic: 8-12 oz./A for conservation reserve, wildflower establishment and other non-cropland only uses.	Quinclorac eradicates a variety of annual grasses, some broad-leaved plants including bindweed. Approximately 76% control is achieved with Quinclorac at 0.5 lb./A plus dicamba at 0.25 lb./A and a crop oil surfactant Sun-It at 0.25G. Best average control is 86% at 0.375 lb./A plus glyphosate at 0.38 lb./A plus 2,4-D at 0.67 lb./A with Sun-It surfactant at 0.25G.
	Foliar treatment for non-selective removal: Glyphosate: 1 to 2 qt./A or 1 to 2% solution.	Paraquat (Gramoxone): kills only tissue that it contacts ("chemical mowing").
Biological Control	No biological control agents have been introduced to control this weed.	No biological control agents have been introduced to control this weed.
Preferred Control Method	Treat with Imazapic or glyphosate in sensitive areas.	Glyphosate applied when bindweed begins to bloom or in the fall when it is actively growing.

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